THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. VII.

No. VII.—JULY, 1910.

ORIGINAL ARTICLES.

I.—Erosion and Deposition by the Indus.

By Arthur Hill, C.I.E., Assistant Secretary P.W.D. Bombay.

[Communicated by the Rev. E. Hill, M.A., F.G.S., The Rectory, Cockfield, Bury St. Edmunds.]

"THE Indus has been eroding severely on the right bank, about 30 miles higher up than the erosion which I told you threatened the railway at Rohri on the left bank. The chord of the curve of the bank attacked was over 2¼ miles long, and the erosion at the apex would be as much as 100 feet a day: it amounted to 3400 feet in forty days. It has given us a good deal of trouble, as with a big breach here the water would travel 120 miles before it would be forced back to the river by the hills on the edge of the deltaic deposits, and loop embankments of great length had hastily to be constructed behind the portions of the flood-embankments threatened with erosion. We succeeded with two loops, but with the third had a breach in the weak new loop; the men have been able to keep it from spreading more than 700 feet wide, and have since got it nearly under control.

"If the bones of the famous geological mule had been on the river bank, they might have been dropped down to the 60 or 100 feet depth to which the river erodes, and have had half a mile of deposits put down alongside them, and between them and the bank of the river; for these channels in bends eroded are filled up again equally rapidly when the river cuts across the chord. So your mule might have had 60 feet depth over him, and the half-mile of new silt alongside him, in three months. The construction of a square mile of new deposits, 60 feet deep, in about two months time, is of almost annual occurrence locally on the Indus. These are, of course, not [pure?] silt deposits; they are merely the land at the side of the river rolled over, as in ploughing.

"Pure silt deposits occur, where the river overtops its natural bank, and in side-channels of the river where the exits are getting smaller than the upstream ends. In the latter case considerable depths, 15 feet or so, of pure silt are deposited in a month or two.

"Most silt probably goes on to the sea. The average discharge of the Indus during 1906, from June to September inclusive, was 400,000 cubic feet per second. . . . The maximum quantity of silt observed in suspension was 2797 grains weight per cubic foot of water. . . . I have not worked out the quantity of silt for the year, but clay weighs about 120 lbs. a cubic foot. . . ."

The above is extracted from a private letter of my brother's, written September 15, 1909, in answer to some questions I had asked relating to the behaviour of rivers. It seems to me likely to interest others besides myself, and he has given me leave to make any use of it. I have printed it as written.

The figures work out as follows:—

The maximum quantity of silt observed in suspension gives a trifle less than 1 cubic foot of clay from 300 cubic feet of water.

The discharge of water in the four above-named months is 4,216,320 millions of cubic feet.

If this contained the observed maximum of silt it would be sufficient to deposit a layer of 1 foot of clay over 503 square miles.

II.—Some Observations on the Brighton Cliff Formation.[1]

By Edward A. Martin, F.G.S.

During the past eighteen years I have made certain observations on the cliff formation on the east of Brighton and on the sections successively brought into view by repeated falls of the cliff. The chief item to be noted from them is, that as the cliff wears back, the base-platform of chalk grows in height, that is, the old surface of the chalk dips towards the south. Also, that the layer of sand which Prestwich found above the chalk grew thinner and thinner, until it has now completely disappeared. At the same time the raised beach has grown in thickness from 1½ feet to 12 feet.

In 1890 the raised beach still remained about a foot and a half thick, as noted by Prestwich, with about 6 feet of sand beneath it. An illustration of the cliffs at this date has appeared in a little work called *Amidst Nature's Realms*, and can be referred to there. An old groyne remained, but it was in a very damaged condition, and it was noticeable that the usual accumulation of beach on the western side had not taken place there. The groyne was subsequently removed, and a low concrete wall was constructed almost as far eastward as where the wooden groyne formerly stood. When visiting the formation in 1892 I noted that there was still about 1½ feet of the raised beach, but between 3 and 4 feet of sand beneath it, the thickness between these limits constantly varying along the face of the cliff, thus showing a considerable reduction in two years.

During a visit to Brighton in September, 1895, the changes which had taken place were very noticeable, owing to the rapid undermining of the cliff formation, and the action of the weather on the porous materials of which it is composed. For many years the eastern limit of the beds had been obscured to a more or less extent, but owing to the great falls that had taken place it was possible to place a limit upon the eastern extension of the beds. This was at a point at about 300 yards east of the Abergavenny Inn. At this point there was a distinct slope upwards of the lines of bedding, these being always more or less obscure, but here sufficiently clear to mark the shore of

[1] Paper read before the Geological Society, an abstract of which appeared in the Quart. Journ. Geol. Soc., May, 1909.

chalk which bounded the small bay in which the 'Elephant Bed' of Mantell had been laid down. The raised beach here gradually ascended and formed a bank resting against the chalk, and the appearance it exhibited was so distinct that there could be no doubt that the utmost limit of the formation was shown. The lines of stratification dipping at various angles to the west were clearly apparent until reaching a point 100 yards westward, where another and larger bank of shingle had been formed, but at a lower level. West of this the strata were so indistinct as to render it almost impossible to say with exactness how the greater number of lines of stratification proceeded. Being subjected to many currents they would appear in all directions and at all dips, supposing that the weight of the overlying strata were sufficient to emphasize current-bedding. At the foot of the Rubble-drift, where the raised beach was exposed in a horizontal position, the thickness of the beach varied from 4 to 5 feet, which was a greater thickness than was to be seen when I visited the cliff in October, 1892. As the cliff had worn backward the raised beach had increased in thickness. Enormous blocks of red sandstone had recently been dislodged from the Elephant Bed, and were lying at the foot of the cliffs, whilst others of smaller size were seen to be embedded in the old sea-beach itself.

Further falls of the Rubble-cliff, and of its chalk foundation, had taken place when I paid a visit in September, 1897. Ten feet of chalk formed the lower portion of the cliff, and above this came the raised beach, as much as 8 feet thick in places, consisting of rounded stones, with very little sandy matrix. The layer of sand at the base of the beach, which in 1892 was from 3 to 4 feet thick, was now represented by a mere trace, and since that date the sand has not again appeared, as the cliff has worn back. The large rounded stones of the ancient beach rested, in fact, almost on the chalk. The Rubble-drift formation above was seen to be distinctly stratified, and as the top of the cliff was reached the flints contained in the loam became more jagged and less rounded. On the existing beach there were strewn boulders of sandstone of all sizes. One large subangular, ruddy-brown sandstone boulder, which had an exposed surface of at least 2 feet long, was seen in situ half-way up the cliff, and at the foot was a mass measuring 5 feet in its largest dimensions, others of smaller size being plentiful. Their place of origin may have been beyond the escarpment of the South Downs.

In April, 1899, the raised beach by further falls of cliff had reached a thickness of 10 feet, resting on 10 feet of chalk. The largest boulders of flint were, strangely enough, on the base of the raised beach, there was no sand, and the change downwards was an abrupt one into chalk in situ. There was no layer of green-coated flints at the junction. Passing towards the eastern boundary of the formation, the beach, instead of being continuous from top to bottom, was seen to be here split up into a top and bottom layer, each of about a foot thick: the space between them was filled with 'reconstructed' chalk, containing many boulders of chalk, these increasing in size easterly towards the limit of the formation, until the whole came to present an appearance as of chalk, almost as originally laid down.

The lower part of the Rubble-drift, which rests upon the topmost gravel, was seen to become more chalky in an easterly direction, and was made up of small semi-rounded fragments of chalk, together with large boulders of the same.

Owing to the manner in which the falls had taken place, the cliff had been cut back more in some parts than in others, with the result that the lines of stratification, which were everywhere most distinct, dipped at a high angle towards the sea on the south. Some of these lines may have been due to current-bedding: in which case it would seem to follow that much of the upper portions of the whole formation is missing, having been planed away with the upper part of the chalk at its rear. Great masses of red sandstone, grey sandstone, and here and there a mass of Tertiary iron-red breccia, strewed the foot of the cliffs. In the raised beach I extracted two rounded boulders of granite, and a few rounded laminæ of green sandstone.

In May, 1899, I noted the following observations. One large mass of red flint breccia, full of angular flints, with the interstices filled with iron sandstone, lay upon the beach at the foot of the cliff, having apparently fallen out of the Rubble-drift. It measured 7 feet long by 4 feet broad, and was 3 feet thick. The flints were not at all worn. There also lay upon the beach a mass of grey sandstone, measuring $4 \times 1 \times 1$ feet, and another of red sandstone, $4 \times 2 \times 1$ feet. Other masses of red sandstone, which in addition to the large one mentioned lay upon the beach, were all fairly rectangular in shape, but the angles were not at all sharp. The blocks appear to have been derived chiefly from the Rubble-drift, Elephant Bed, or Coombe Rock, as it has been variously called, whence came also a large slab of chalk rubble, full of rounded chalk lumps and occasional flints, which measured 2 feet long by 1 foot wide, but only averaging 3 inches in thickness.

On the raised flint beach (below the Rubble-drift) round boulders of chalk of large size occasionally occurred: in one place, in a very small area, there were thirty and more to be seen. In this there were also occasional masses, fairly rounded, of red sandstone, generally occurring near the base of the old beach. Similar blocks in the Rubble-drift are much more angular. Beneath the disused black-tarred coastguard houses, there remained now but a few feet of Rubble-drift.

A little east of the Abergavenny Inn, the stratification of the Rubble-drift is rather remarkable. A mass of reconstructed chalk appears to have found its way to the bed of the estuary, soon after the raised beach ceased to be formed, and impeded the horizontal deposit of the drift above it.

Seen again in June, 1903, the formation showed considerable changes in consequence of falls, and in the raised beach more particularly. Being the most loosely accumulated portion of the whole formation, the falls had occurred so as to leave cave-like gaps, with a platform of chalk 14 feet thick below, and a roof of comparatively loose gravel and clayey sand. The raised beach itself was 8 ft. 3 in. in thickness, and this was fairly constant throughout the whole distance of 200 yards in which the beach was visible.

In those parts where the base of the beach was clearly visible,

there was a foot of larger flint stones than those contained in the main mass, and large blocks of red sandstone were visible, both at the top and at the base of the beach. About 100 yards east of the most westerly visible portion of the beach it began to enclose large sub-angular blocks of chalk, and became of a more and more chalky nature in an easterly direction.

It was not always easy to say definitely where the series of deposits ended in an easterly direction, and where the chalk commenced to again appear in situ. At somewhat over 200 yards to the east of where the formation is first seen, in travelling from the direction of Brighton, the gravel suddenly drops to about 6 inches in thickness, whilst upon it is chalk which has apparently been moved and redeposited. We appear here to be at the bank of the estuary down which the material was being transported, and the disturbed chalk has been deposited in the shallow water near the banks. In the same way the gravel has here been deposited very sparingly, most of it having been rolled into the central parts of the stream.

So far as the Rubble-drift is concerned the section as it now appeared was most clearly and distinctly stratified. Especially was this noticeable in that portion nearest to Brighton, where it is made up for the most part of alternate thin bands of pale reddish clay and thicker bands of chalky rubble. The pieces of chalk in the rubble are rounded in the form of pebbles, varying in size from a pea to a small plum.

About midway along the section where, in the raised beach underneath, the large blocks of chalk begin to appear, there is in the Rubble-drift, about two-thirds the way up the cliff, a remarkable band, 2 feet thick, of dark reddish clay, in which are contained large numbers of rounded chalk pebbles, the band standing out distinctly in the cliff by reason of the clay being of a darker red colour than the surrounding clay.

Large blocks of red sandstone were visible in the Rubble-drift. On the present beach I counted in a space of 50 yards square no less than forty fallen blocks, each containing on an average 8 cubic feet capacity. There were many others lying at a greater distance, but among them all I saw only three which were conglomeratic. All the others were hard red sandstone.

Standing on the rocks at low tide I could not help being struck by the appearance presented at the top of the chalk cliffs where the degradation of the chalk was going on. The line of demarcation between the chalk and the subsoil was arranged in the shape of festoons, each festoon being 2 to 3 feet across, and extending from 3 to 5 feet from the surface. Sometimes in the flinty clay resulting from the degradation a festoon had been left of white chalk untouched, whilst beneath it decomposition had proceeded. I had on a previous occasion noticed this festoon degradation in the chalk in cuttings in the neighbourhood of Birchington. It is still to be observed. A few fragments of shells (*Mya*) were found at the top of the raised beach.

A visit to the cliff in December, 1906, showed that there had been a tremendous fall since my last visit at a site not far to the east of the Abergavenny Inn. This had exposed a great rounded chalk block

about 2 feet long, interstratified with the raised beach, whose thickness varied from 15 to 20 feet. The section nearest to the concrete wall on the west was as follows: chalk rising out of existing beach 10 to 17 feet, containing thick bands of flint. Above this a thickness of about 6 feet of raised beach, with some small sandstone boulders exposed therein. As the cliff recedes by denudation it will be seen that the raised beach varies in thickness, so that apparently it was laid down upon a floor that was not at one level.

On my visit in June, 1907, great masses of the cliffs appeared to be slipping away in all directions, ready to fall at subsequent recurrences of wet or frosty weather.

In visiting the section again in September, 1908, I found that the chalk base had been cut into considerably by the sea, so that three or four little bays had been formed. That nearest to the concreted embankment was about 100 yards across. Here the section was as follows: the lowest 12 feet of chalk had been faced by concrete, above which 5 feet of chalk was exposed. Next above came 12 feet of pebbles, the largest stones being at the base, and the topmost being much mixed with sand. Then came 10 feet of stratified rubble, the remainder to the top of the cliff being, as a rule, but obscurely stratified. Beyond the baylet in which this section occurred the formation was well exposed for about 100 yards beyond the abandoned inn at the top of the cliff, and close to the site of the great fall of two years before. Nearly all of the material which then fell had, however, disappeared; there was a little of it remaining, reaching to about 17 feet up the cliff. There was still exhibited about 250 yards of the formation as a whole, reckoning east and west along the face of the cliff.

It will not fail to be observed that in spite of the large amount of rubble which is constantly falling but little accumulates as a talus at the foot of the cliffs. The floor will be seen to consist almost entirely of chalk. It will occur to students of coast-erosion that this material will have to be prevented from being carried away if the cliffs are to be preserved. Even the lowest tide shows no trace of the material, and there must therefore be undercurrents which carry away the debris into deep water. Only the sandstone and chalk boulders remain for any considerable length of time.

III.—Sedgwick Museum Notes.

New Fossils from the Dufton Shales.

By F. R. Cowper Reed, M.A., F.G.S.

(PLATES XXIII AND XXIV.)

(*Concluded from the May Number, p. 220.*)

Part III.

BRYOZOA.

Crisinella Wimani, sp. nov. Pl. XXIII, Figs. 1–3.

Zoarium composed of a group of branches of equal size diverging in a fan-shaped manner in nearly the same plane from a single short

somewhat stouter stem; the branches originate and increase by repeated bifurcation, which takes place at uneven intervals proximally, and most frequently near the stem where the branches also are less regularly disposed and somewhat flexuous; but further from the base the bifurcation is rare and more regular, and the distal portions of the branches are nearly straight and sub-parallel or only very slightly divergent. Zoœcial openings present only on one side; zoœcia arranged in 3–4 longitudinal rows, the outer row on each side composed of regularly disposed equidistant zoœcia of equal size and placed alternately; peristomes prominent, laterally projecting outwards as short sharply triangular spines directed forwards and situated about one to one-and-a-half times the diameter of the branches apart; zoœcia in the one or two inner longitudinal rows without prominent peristomes, opening obliquely on the face of the branches, smaller than the lateral rows, and somewhat irregularly arranged. Reverse face of branches non-celluliferous, minutely pitted.

		mm.
Dimensions.	Length of zoarium . .	about 20·00
	Width of zoarium . .	about 25·00
	Width of branches . .	about 0·75

Remarks.—We may compare this species with *Cr. œlensis*, Wiman,[1] from the Borkholm Beds, but the zoœcia of the lateral rows in the latter do not project so much, and the reverse face is stated to be smooth.

BRACHIOPODA.

Orthis duftonensis, sp. nov. Pl. XXIV, Figs. 5–11.

Shell sub-quadrate to transversely semi-elliptical, usually rather wider than long and widest across middle; biconvex to flattened; valves shallow. Hinge-line straight, slightly less than maximum width of shell; cardinal angles sub-rectangular to obtuse. Pedicle-valve sub-conical, weakly convex; hinge-area large, triangular, not steeply inclined, but making an angle of 60°–75° with general surface of valve, striated parallel to hinge-line, and crossed by rather narrow triangular delthyrium; beak not incurved. Brachial valve very slightly convex, not so deep or conical as pedicle-valve, more or less flattened; faint median longitudinal depression occasionally present; hinge-area narrow, triangular, about one-third the width of that of opposite valve and steeply inclined to it, but only making an angle of about 20° with general surface of its own valve; delthyrium narrow triangular; beak inconspicuous, small, not incurved. Surface of valves regularly ornamented with 40–45 simple straight narrow rounded equidistant prominent radiating ribs, continuous from beak to margin, of equal strength, separated by equal rounded concave interspaces one-and-a-half times to twice the width of the ribs; interspaces marked by numerous regularly and closely set concentric lines or lamellæ becoming weaker or obsolete in passing over ribs. A few shorter ribs, not more than 6–8 on a valve, are generally intercalated, arising at one-third to one-half the length of the shell, and

[1] Wiman, Bull. Geol. Inst. Upsala, 1909, No. 10, vol. v, pt. ii, p. 181, pl. vi, figs. 12–16.

rapidly attaining the size of the primary ribs; and being set at the same distance apart they are indistinguishable at the margin from the primaries.

Interior of pedicle-valve with short triangular hinge-teeth and small sub-ovate muscle-scar, about one-fourth the length of the valve, rather deeply sunk and circumscribed by a ridge, weakly bilobed in front and composed of two small diductors separated by very narrow linear adductors. Pair of median vascular sinuses, contiguous and parallel at first, run forwards from muscle-scar, ultimately diverging and curving outwards laterally.

Interior of brachial valve with narrow straight linear cardinal process borne on rather massive thick hinge-plate, continued anteriorly as broad low rounded ridge between deeply sunk but indistinctly defined posterior adductors; anterior adductors not visible; dental sockets deep, with strong walls and stout prominent triangular crura.

Average Dimensions.—Length 30 mm.; width 25 mm. The smaller (younger) examples are usually somewhat broader.

Remarks.—In shape this shell much resembles some examples of *O. calligramma*, Dalm., but the species *O. plicata*, Sow.,[1] which Davidson regarded as merely a variety of it, is closely similar, especially in internal characters, but the cardinal angles are not really pointed or mucronate in *O. duftonensis* (though internal casts often give an erroneous impression), nor are the ribs angular, nor the interspaces of less width than the ribs. The typical *O. calligramma* is more convex, the beak of the pedicle-valve more incurved, and the ribs fewer, but its general shape and internal characters are very similar, and it agrees also in the simplicity of the ribs and ornamentation. The form ascribed to this species by Wiman,[2] from the Asaphus Limestone of the Baltic province, appears to bear a considerable resemblance to our species.

So much confusion and indefiniteness has been caused by putting well-marked varieties (or species) occurring on different stratigraphical horizons into *O. calligramma*, that it seems desirable to separate specifically this very strongly characterized local form under the name *duftonensis*.

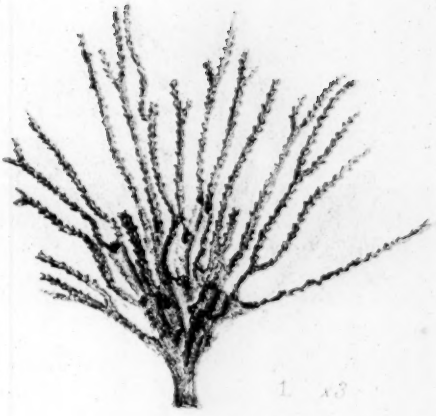
Orthis melmerbiensis, sp. nov. Pl. XXIII, Figs. 4–8.

Shell sub-quadrate, strongly folded along median line with dependent lateral lobes; anterior margin angulated strongly in middle; hinge-line straight, equal to or slightly greater than width of shell; not auriculate. Pedicle-valve swollen, convex, angulated longitudinally down middle, sub-carinate, with lateral portions hanging down and flattened; beak small, elevated, prominent, rising above hinge-line, slightly incurved; hinge-area triangular, rather large, vertical or steeply inclined. Brachial valve divided into two lobes by strong deep median sulcus, rapidly increasing in depth and width towards front margin, which is angulated; beak small, with narrow hinge-area. Exterior of shell ornamented with about 30 fine, closely set

[1] Davidson, *Brit. Foss. Brach.*, vol. iii, p. 245, pl. xxxv, figs. 25, 26; pl. xxxvii, fig. 1.

[2] Wiman, Bull. Geol. Inst. Upsala, 1907, vol. viii, p. 103, pl. vii, figs. 28–30.

3. x10.

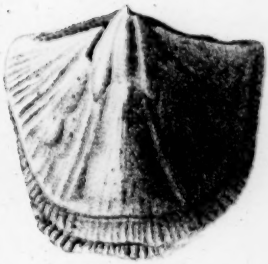


1. x3.

2. x10.

4a. x5.

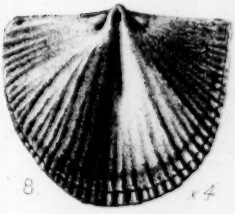
4. x5.



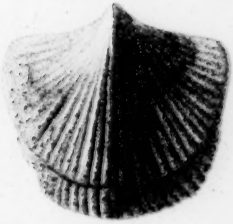
5. x4.

4b. x12.

6. x5.



8. x4.



7. x6.

A. H. Searle del. et lith.

West, Newman imp.

New Fossils from the Dufton Shales.

subangular ribs, nearly straight, equidistant on margin and of equal size, mostly dividing at one-fourth to two-thirds their length and each bearing a single row of rather distant short tubular erect spines, specially developed on the lateral portions of the valves; a fine close concentric lineation is also present. Interior of pedicle-valve with short impressed sub-triangular muscular scar widening anteriorly and broadly excavated in front, about one-third the length and width of the valve and composed of a pair of divergent diductors enclosing elongated oval adductors; occasionally two straight narrow divergent vascular ridges are traceable running forwards from the anterior outer angles of the muscular scar to a concentric sub-marginal ridge (often present). Interior of brachial valve with small rounded knob-like cardinal process; no thickened hinge-plate; crura short, sub-triangular; low narrow median ridge running forwards for about one-half the length of valve from cardinal process; muscle-scars indistinct.

		mm.
Dimensions.	Length . .	7·5
	Width . .	9·0

Remarks.—This shell somewhat resembles *O. cespertilio*,[1] Sow.; but the ornamentation is different and the internal characters are not quite identical, the cardinal process is not raised on a hinge-plate nor the adductor muscles deeply sunk, while in the pedicle-valve the muscle-scar is not saucer-shaped, but triangular and sub-bilobate; the submarginal ridge and hollow spines also are special features. It might be thought that this shell is merely a variety of the protean *O. testudinaria*, Dalm., using this specific name in the loose and comprehensive manner customary. But it seems undesirable to stretch this species yet more; and indeed the internal characters and surface-spines are quite sufficient to separate the Dufton form.

Orthis (Scenidium?) equivocalis, sp. nov. Pl. XXIV, Figs. 1–4.

Shell transversely sub-fusiform, widest along hinge-line, with acutely angular cardinal extremities. Pedicle-valve strongly convex, most so in middle portion, cardinal angles somewhat flattened; beak high, incurved, with triangular, steeply inclined hinge-area; muscular area about one-third length of valve, sub-quadrate, not deeply impressed, divided into two pairs of sub-parallel scars, the outer ones being the diductors; teeth short, strong; small apical foramen apparently present. Surface of pedicle-valve furnished with pair of equal median ribs, smaller than the rest, and rather more closely placed, with 7–8 stronger subangular ribs on each side, very slightly curved and somewhat decreasing in strength towards lateral angles. Brachial valve moderately convex, but much less so than opposite valve; bilobed, with shallow median sinus widening anteriorly to over one-third the width of the valve; small, inconspicuous beak, and narrow hinge-area; narrow linear septum present, about one-fourth the length of the valve, with sub-parallel crural plates of same length on each side; muscular impressions indistinct. Surface of brachial valve with single straight median rib rather smaller than the rest, flanked

[1] Davidson, *Brit. Foss. Brach.*, vol. iii, p. 236, pl. xxx, figs. 11–21.

by 8–9 simple subangular straight ribs on each side, decreasing in strength towards lateral angles, and equal to or rather narrower than the subangular interspaces, which occasionally show a fine central line down them. In a few cases a small secondary rib arises close to the margin on the flank of a primary rib on either valve, but it is always short and inconspicuous. Surface of valves covered with coarse punctæ (showing as sharp pustules on an impression of the outer surface) arranged with some regularity in concentric and radial rows.

		mm.
Dimensions.	Length . .	5·5
	Width . . .	8·0

Remarks.—This little shell is much like some species of *Scenidium*, the character of the ribbing and punctation, as well as the shape of the shell, recalling members of this genus. We may especially compare *Sc. ælandicum*, Wiman,[1] from the West Baltic Leptæna Limestone. The non-formation of a spondylium in the brachial valve is, however, an important difference, but Hall & Clarke[2] have pointed out that there are transitional forms between *Orthis* and *Scenidium*, and probably this species is such. It cannot be regarded as the young or a variety of *O. actoniæ*, Sow., the details of the ribbing and punctation, as well as the internal characters, being distinctive.

Postscript. Since the May number of the Geological Magazine was issued Dr. Marr has pointed out to me that there is some doubt as to whether the beds from which the above-described fossils were obtained are strictly referable to the Dufton Shales in the recent and restricted use of the term. Lithologically the rock resembles the Corona Beds and contains *Lingula tenuigranulata*. However, Professors Harkness and Nicholson employed the name Dufton Shales in a wide sense, including in them the Corona and other beds, and it is with this earlier and broader application that the term must be here understood. It is unfortunate when the same term has thus been used with two different meanings, particularly as it results from an alteration of its original significance.

EXPLANATION OF PLATES XXIII AND XXIV.

Plate XXIII.

Fig.
1. *Crisinella Wimani*, sp. nov. Zoarium. × 3.
2. Ditto. Celluliferous side of branch. × 10.
3. Ditto. Reverse side of branch. × 10.
4. *Orthis melmerbiensis*, sp. nov. Internal cast of pedicle-valve. × 5.
4*a*. Ditto. Anterior marginal view of same specimen. × 5.
4*b*. Ditto. Portion of surface of same valve. × 12.
5. Ditto. Internal cast of pedicle-valve. × 4.
6. Ditto. Ditto. × 5.
7. Ditto. Wax squeeze of pedicle-valve, showing ribbing. × 6.
8. Ditto. Internal cast of brachial valve. × 4.

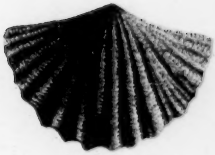
Plate XXIV.

1. *Orthis* (*Scenidium*?) *equicostalis*, sp. nov. Impression of brachial valve. × 5.
2. Ditto. Internal cast of same brachial valve. × 5.
3. Ditto. Impression of pedicle-valve. × 4.

[1] Wiman, *Arkiv f. Zool.* (Stockholm), 1907, Bd. iii, No. 24, p. 7, t. i, figs. 5–11.
[2] Hall & Clarke, *Palæont. N. Y.*, vol. viii, Brach. i, p. 241.

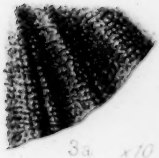
1. ×5

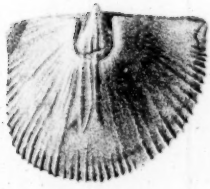
2. ×5


3. ×4

4. ×5

7.


3a. ×10


6.

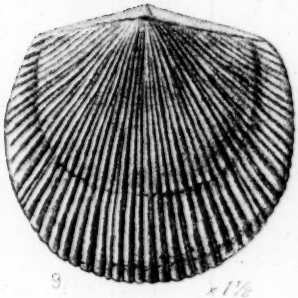
5.

8.

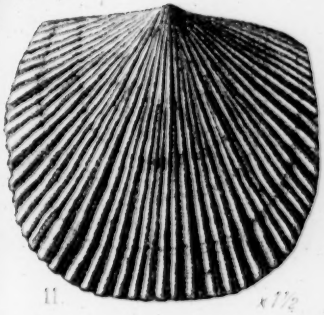
9a. ×1½

9b. ×1½

10.


9. ×1½

9c ×2½


11. ×1½

A. H. Searle del. et lith. West, Newman imp.

New Fossils from the Dufton Shales.

FIG.
3*a*. *Orthis* (*Scenidium*?) *equivocalis*, sp. nov. Portion of surface of same valve. × 10.
4. Ditto. Internal cast of same pedicle-valve. × 4.
5. *Orthis duftonensis*, sp. nov. Internal cast of brachial valve. Nat. size.
6. Ditto. Internal cast of pedicle-valve. Nat. size.
7. Ditto. Internal cast of brachial valve. Nat. size.
8. Ditto. Internal cast of pedicle-valve. Nat. size.
9. Ditto. Brachial valve of complete specimen. × 1½.
9*a*. Ditto. Posterior view of same specimen. × 1½.
9*b*. Ditto. Lateral view of ditto. × 1½.
9*c*. Ditto. Portion of surface of ditto. × 2½.
10. Ditto. Brachial valve of another complete specimen. Nat. size.
11. Ditto. Pedicle-valve of another complete specimen. × 1½.

IV.—On the occurrence of Wind-worn Pebbles in High-level Gravels in Worcestershire.

By Leonard J. Wills, M.A., F.G.S., Fellow of King's College, Cambridge.

(PLATE XXV.)

WIND-WORN pebbles are somewhat rare in England, and accordingly it may be of interest to record the occurrence of a deposit of which they form a prominent feature. This has been met with in several quarry-sections at Hill Top, near Bromsgrove in Worcestershire, at about 350 feet above sea-level. I am indebted to Mr. Willcox, the owner of one of the quarries, for pointing out these pebbles to me.

The quarries are opened in the Lower Keuper Sandstone, and the deposit under consideration occurs on the ridge of the hill in channel-like depressions cut out of the underlying sandstone. To the north-west there are patches of gravel capping the hill, but so far I have not detected wind-polished pebbles in them, and I am rather inclined to regard the two deposits as distinct.[1]

As exposed in the quarries, the deposit is a loose red-brown sand, with occasional streaks of tough clay, and may attain a thickness of about 10 feet. In places the sands are blackened by an infiltration of an oxide of manganese. In cases where pebbles lie in clay, sand-grains may be cemented to them by this oxide. The sand is largely composed of fairly fine quartz-grains, usually angular, and rarely rounded, but there is also a great quantity of very much smaller and quite angular material, and a few large flakes of white mica.

The wind-worn pebbles lie in a somewhat discontinuous layer towards the base of the deposit and occasionally higher up in it. They are, as I hope to show, more or less highly polished, according to the nature of the material of which they are composed, but nearly all show a dimpling which has resulted from the selective action of the wind. These little depressions are polished like the rest of the stone. But possibly the most striking feature that nearly all of the pebbles show is the presence of sharp angular ridges, which give

[1] One large quartzite pebble, having a very typically wind-cut appearance, has been found about 1½ miles to the north-east of Bromsgrove, while other pebbles with a considerable polish may be seen in the fields near Apesdale. So it is possible that similar deposits to those at Bromsgrove may eventually be discovered in that neighbourhood also.

them a more or less facetted appearance. I have not been able to convince myself that any large face has actually been produced by the wind, but natural fractures and pre-existing faces have been ground down, and the sharp intervening ridges have been preserved and accentuated. This could not possibly have come about under water.

It may be of interest to examine the manner in which the same erosive action has affected different kinds of rocks. The pebbles found are capable of derivation either from the Bunter Pebble Beds or from glacial deposits.

1. Pebbles probably derived from the Bunter.

(1) *A mottled green and purple grit* (Pl. XXV, Fig. 1).—On the side shown in the figure a typical dimpled surface with a greasy lustre is seen, while the other side preserves the water-worn contours that it possessed in Bunter times. The sharp edge seen round the outside is to be noticed, since it gives evidence of actual cutting power in the sand-blast.

(2) *A small pebble of black felstone with veins of quartz* (Pl. XXV, Fig. 2).—This is polished all over. The sharp line up the centre, shown in the photograph, possibly indicates an edge modified by wind-action, as a result of the grinding down and remodelling of a natural fracture. In this way a rude dreikanter form is obtained. It is possible, though I do not think it probable, that the shaping is entirely due to wind-action. The selective action of the sand-blast is seen in the way the quartz veins stand out.

(3) *Coarser grits.*—These are chiefly noticeable in regard to the projection of the quartz-grains and to polishing of the depressions between.

2. Pebbles probably derived from Glacial Deposits.

(1) *North Welsh Andesitic Ashes.*—Boulders of this kind are common and may attain a large size (up to 13 or 14 inches through). They vary slightly in composition, but they nevertheless show much the same external phenomena. They are not so highly polished as are the quartzite and quartz pebbles derived from the Bunter, but are characterized by an irregular pitting and grooving. The latter is really more comparable to the elongation of the pits in a common direction than to actual grooving. In a very coarse ash with large quartz-grains these stand out and are well polished.

(2) *Felspathic Grits* (probably Carboniferous).—Two specimens of very similar grits have been found. One is about 9 inches long and shows the effect of the wind-erosion on the rock as a whole, whereas the other is quite small and, though equally angular, is instructive as illustrating the selective action of the wind on heterogeneous material. The sides of the larger stone have the softer parts worn away in more or less parallel strips. Its lower surface is irregularly flaked and barely polished at all.

(3) *Silicified Crinoidal Limestone* (Pl. XXV, Fig. 3).—These pebbles take a very high polish and look as if they had been rubbed with oil. There are occasionally deep round pits in them which are not so well

polished. These represent the hollow casts of crinoid stems. It may be noted that these silicified limestones are always more or less angular, but this does not preclude the possibility that they have been derived from the Bunter.

(4) *Gannister* (Pl. XXV, Fig. 5).—A very fine specimen of a gannister pebble is here figured. It was found by Mr. Willcox, who sent it to me. On the reverse side it is smooth but not intensely polished, whereas on the side figured a very high glaze is seen. More remarkable still is the sharp angular ridge which surrounds the top of the stone. The upper surface has an appearance as if the rock possessed a slight conchoidal fracture along which pieces had flaked off under the influence of frost. The hollows left have been highly polished, and the ridges between are quite sharply defined and angular. At (*a*) we can see how the erosive agent has picked out a natural joint in the rock and enlarged it.

This fine specimen gives strong evidence in favour of the conclusion that these cases of polishing are due to the action of wind-erosion, for it is evident that the wind is the only agent capable of polishing concave surfaces and, at the same time, of leaving the ridges between the depressions sharp.

In most of the cases considered above where a dreikanter form has been observed, it is due to accidental fracture. But there are instances where one is tempted to say that the general shape is the direct result of cutting by a sand-blast, the pebble having a roughly tabular form with a flattish upper surface surrounded by a sharp ridge. Such shapes are common among desert pebbles from Wadi-Halfa in Egypt, and may there represent the first stage in the production of a dreikanter. A specimen of this type preserved in the Sedgwick Museum, Cambridge, is here illustrated on Pl. XXV, Fig. 4, and may be compared with Pl. XXV, Fig. 5.

It is striking that the sand in which the stones lie is composed of angular material. But it is at the same time to be remembered that wind-rounded sand-grains are almost always of larger size than those found here.

The presence of Welsh erratics among these polished pebbles fixes the age of the deposit as either Glacial or post-Glacial. This is of interest since, throughout North Germany, wind-cut pebbles are found lying on the Boulder-clay at the base of the Loess. In England too one wind-cut pebble has already been recorded which was probably derived from glacial deposits.[1]

The remaining records of wind-polished stones in England (other than recent) show that probably their production was a rather local phenomenon and not likely to be very widely observed. Further, they are not confined to beds of one age. Mr. Clement Reid, to whom my thanks are due for help in dealing with this question, mentions some from Dewlish, where they appear to be late Pliocene or of the age of the Cromer Forest Series.[2]

Prestwich[3] found similar pebbles at Portland. They were there

[1] F. A. Bather, Proc. Geol. Assoc., 1900, vol. xvi, p. 396.
[2] C. Reid, "Pliocene Deposits of Britain": Mem. Geol. Surv., 1890, p. 206.
[3] J. Prestwich, Quart. Journ. Geol. Soc., 1875, vol. xxxi, p. 29.

associated with *Elephas antiquus*, *E. primigenius*, and *Equus fossilis*, etc. Their age is probably post-Glacial.

A second record by Mr. Clement Reid is of especial interest to us. He found Palæolithic gravels with polished pebbles at Savernake Forest, and his comments on the climate of those times are pertinent. He argues that it must have been milder than on the Continent, where steppe conditions were prevailing, and yet that "we have indications of drought in some of the mollusca and small mammals—perhaps also in the extreme poverty of the flora".[1] Yet the palæontological evidence in favour of steppe conditions is still meagre. *Lagomys pusillus* and *Spermophilus* are known from the Ightham Fissures, while the Saiga antelope is recorded from the Thames Valley. These, in that they are quite typical steppe animals, should form good evidence of the prevalent climate.

I think, therefore, that we are justified in putting this occurrence of wind-worn pebbles on record, as another possible link in the chain of evidence in favour of dry conditions verging on those of the present-day steppes having occurred locally in Great Britain in post-Glacial times. The abundance of fluviatile deposits belonging to this period precludes the possibility of true steppes having existed over wide areas in our country. But at the same time, though the melting and retreating ice-sheet provided great quantities of water, yet the climate may have been fairly dry, especially if, as Mr. Harmer has suggested, the prevalent winds blew at that time from the east. It must, however, be confessed that the general prevalence of steppe conditions in this country is still very far from proven.

EXPLANATION OF PLATE XXV.

Fig. 1. Wind-worn pebbles of fine-grained felspathic grit. $\frac{2}{3}$.
" 2. " pebbles of black felstone. $\frac{2}{3}$.
" 3. " pebbles of silicified limestone. $\frac{2}{3}$.
" 4. " pebble from Wadi-Halfa, Egypt. $\frac{2}{3}$.
" 5. " pebble of Gannister. $\frac{1}{2}$.

Figs. 1–4 photographed by author; Fig. 5 by W. Tams.

V.—The Upper Keuper Sandstones of East Nottinghamshire.[2]

By Bernard Smith, M.A., F.G.S.

(PLATE XXVI.)

THE Keuper rocks of East Nottinghamshire occupy almost the whole of that part of the county, striking slightly E. of N. and W. of S., and dipping at a very low angle in an easterly direction.

They have been described by many competent local observers such as the Rev. A. Irving, Messrs. J. Shipman, E. Wilson, J. F. Blake, W. J. Harrison, and A. T. Metcalfe; and also by W. H. Dalton and W. T. Aveline in several publications of the Geological Survey between 1879 and 1888. During the recent survey the succession

[1] C. Reid, *Summ. Prog. Geol. Surv. Gt. Brit.* for 1902, p. 207. See also the same author in *Nat. Sci.*, 1893, vol. iii, p. 367.

[2] With the permission of the Director of the Geological Survey.

Wind-worn pebbles.

has been mapped and described once more,[1] but in no case has particular attention been paid to the composition and structure of the sandstones of the Keuper Marls, which are usually dismissed by writers in as few sentences as possible. The following notes collected between 1906 and 1910 may therefore serve a useful purpose in supplementing previous descriptions of the Marls, and may throw light upon the probable method of accumulation of this somewhat monotonous formation.

Surface Features.—The sandstones of the Keuper Marl of Nottinghamshire are locally known as 'skerries', and the relief and characteristic appearance of the outcrop is directly due to these 'skerries' with their associated beds—a combination which I shall refer to as 'skerry-belts'. In the almost complete absence of drift the marls have weathered in such a way that practically every feature is the expression of some resistant bed which may be quite invisible at the surface. In rare cases this may be a hard blocky marl, but usually it is a skerry-belt.

If the Keuper Marl plateau, where least dissected, is followed in the direction of the dip, the successive skerry-belts encountered—unless individual skerries are very thick and hard—do not make much show, but come on gradually, first the lower layers and then the higher ones. When, however, the plateau is well dissected, the beds forming the belt stand out boldly, especially where the strike-streams trench the upland close to the now well-developed escarpments.

In the north-eastern part of the county the lower skerries form an upland gently sloping in an easterly or south-easterly direction drained by dip-streams flowing to the Trent. Standing upon one of the divides between the valleys and looking north or south, ridge after ridge, supporting village after village, may be seen at the same level. From this level the slopes drop in steps over successive skerry-belts to the valley bottoms, the edge of each remnant of the upland being the edge of the valley upon that side; hence the characteristic scenic effect is the straight sky-line, whether in long ridges or isolated hills.

Skerry-belts.—The skerry-belts—usually about 6 feet thick—are composed of alternations of micaceous sandstone, shale, and marl with occasional veins of fibrous gypsum, and are unexpectedly persistent, although individual beds of stone may occasionally thin out whilst others become thicker.

The sandstones vary from an exceptional thickness of 3 feet to less than half an inch, the thicker beds being often split up by sandy shales. In the belts it is common to find (in upward succession) red marls and clays followed by a thin layer (1–2 inches) of green and blue clay, which is succeeded abruptly but conformably by a sandstone. Above the latter there is a gradual passage through green to green-red and finally red clays and shales. Pseudomorphs after salt crystals, formed at the surface of the green-blue clay, are frequently found on the bottom surface of the sandstone. The sandstones are pale in

[1] "The Geology of the County between Newark and Nottingham": Mem. Geol. Surv., 1908, pp. 35–54, and in *Summaries of Progress* for 1907–8.

colour (white, cream, grey-green, or pale-blue), but if thin may be stained pink externally. The shales often have the 'watered' appearance characteristic of the Waterstones,[1] and were evidently formed under the same conditions. Chocolate or bright-red marl frequently passes abruptly into bright-green marl in both a vertical and horizontal direction. Small galls of red marl up to half an inch in length frequently occur in the green shales and green ones in the red shales, and it is noticeable that the green shales are often of a coarser texture than the red.

The Skerries.—Mr. W. H. Dalton[2] describes the majority of the sandstones in the Keuper Marl as "very fine-grained, compact, grey or even pure white, and very hard; in the latter case containing a high percentage of carbonate of lime . . . It is too soft for traffic, but hardens considerably by exposure, which permits of the deposition of crystalline carbonate of lime previously in solution in the pores of the stone. The cementing material appears to be wholly carbonate of lime, the rock falling into sand by submersion in hydrochloric acid". He further adds that there are "thin bands of sandstone, sometimes rather coarse, soft, and of the same deep colour as the marls". These last-mentioned sandstones are thin and so scarce that they are almost unnoticeable, and pink in colour rather than deep red, like the marls. On hammering they generally expose a pale core, which suggests that the reddish tint is due to weathering.

The skerries fall into three types in ascending order—

1. Pale sandstones with carbonates.
2. Pale flaggy sandstones with more silica.
3. Coarse sandstones with larger rounded grains, mostly siliceous.

1. These form the main stone horizon near the base of the division, and give rise to the most characteristic plateau features. They frequently exhibit drift-bedding and ripple-marking, or show a peculiar contorted arrangement of the laminæ (suggestive at first sight of concretionary action). Here and there lumps of softer laminated stone lie rolled up and embedded in non-laminated portions and tend to weather out, giving the stone a honeycombed appearance.

Two slices were examined microscopically, and in both cases the rock contained quartz and carbonates in about equal proportions. The first was a compact typical building stone (Maplebeck, Notts), slightly banded. It consists of small angular quartz-grains of very similar size and derived rhombs of dolomite. The dolomite never occurs as plates enclosing the quartz-grains, but as rhombs of various sizes, *with rounded angles and broken faces.* A little calcite may be present, but is not very much in evidence. The quartz-grains—generally less than $\frac{1}{10}$ mm. in diameter—are derived from plutonic rocks and are full of fluid cavities. The banded appearance is due to the scarcity of quartz, which drops from 50 to 10 per cent. along certain lines, and must therefore be due to sedimentation.

The second example was a softer-looking ripple-marked rock,

[1] The term originally used by Mr. G. W. Ormerod, because the surfaces of some of the beds had a watery appearance, like watered silk.

[2] "The Geology of the Country around Lincoln": Mem. Geol. Surv., 1888, p. 8.

similar to the last, but in which the quartz-grains are of more uneven size. The laminæ of the ripple-marks are in this case due to either dolomite or quartz rising to 90 per cent., as compared with 10 per cent. of the other constituent. Part of the rock is patchy, i.e. contains nests of quartz or dolomite in the above proportions. The quartz shows strain shadows, and the larger grains ($\frac{1}{10}$ mm.) contain fluid cavities with gas bubbles. The dolomite granules, much smaller than the quartz-grains, are often stained with limonite. There are a few accessory minerals of no great importance, such as magnetite, zircon, sphene, and a pale pleochroic greenish-brown mica.

2. The second series commences at from 360 to 370 feet above the base of the Keuper Marls, and consists of thinner and less persistent sandstones than those of the lower series. They have a siliceous, often banded, appearance, and weather out as rough, slaggy-looking pieces of stone, with a brown or blue-black stain due to iron or manganese compounds, strikingly different from the paler and cleaner fragments of the lower skerries.

A slice of a wavy-banded specimen shows that the light bands (reflected light) consist of quartz with small brightly polarizing dolomite granules or rhombs, which make up perhaps 30 per cent. of the rock. The remaining 70 per cent. is mostly quartz with a little accessory twinned felspar (microcline and anorthoclase). The angular quartz-grains (all about $\frac{1}{10}$ mm. in size) show strain shadows, and occasionally pack as a mosaic with little or no dolomite between them. Some appear to be cemented together or to be parts of a previous quartzite. A little detrital calcite mud may be present, and angular cavities in the slice may represent plates of that mineral.

3. In hand-specimens the third type consists of flaggy and false-bedded sandstones, in colour white to bright-red, resembling millet-seed sandstones with rather loosely cemented grains. These rocks are found some 120 feet below the base of the Rhætic beds, or about 580 feet above the base of the Keuper Marls.

Under the microscope the grains are seen to be of two sizes. The larger are often beautifully rounded, and average $\frac{1}{2}$ mm. in size; the smaller are of similar composition, but more angular, occupying the interstices between the first. The majority consist of quartz (percentage over 95), with strain shadows and fluid cavities with bubbles, and there has sometimes been a secondary growth of silica upon the surfaces of the grains. Felspar with fine lamellar twinning (? oligoclase), fine quartzites, and quartz-schists are also present. An interesting point is the appearance of several grains composed of dolomite and quartz, having the appearance of rolled fragments of a rock resembling that last described.

Ripple-marks and Contorted Structures. — These structures are commonly found in the lower sandstones, but are not confined to them. There seems to be no doubt that the drift-bedding and ripple-drift was the result of water-action, one set of ripples being sometimes partially destroyed and another laid down in a slightly different position (Fig. 1). Occasionally the same slab shows ripples crossing a second set at right angles.

In the first two skerry types the quartz fragments and dolomite

fragments are very even grained, their different percentages in the laminæ being doubtless due to oscillations in the amount of supply during sedimentation. The smaller size of the dolomite grains, as compared with the quartz, may be explained by the higher specific gravity of the dolomite.

The contorted structure shown in Pl. XXVI, Fig. 1 is not so easily explained. If the upper part of such a slab is stripped off—as it often is by weathering—an irregular lumpy surface, consisting of smooth curves and folds, would be exposed. This appearance, taken in conjunction with the occurrence of dolomite, is suggestive of concretionary action; I would, however, attribute it mainly to disturbance of the ripples while the deposit was still in a soft and pasty condition. In a few cases, however, there is a suggestion that in addition to ripple-marks the layers of sediment were arranged in rounded curves (somewhat like those in some parts of the Cotham Marble), but afterwards disturbed by current-action. Freshets of water, producing swirling currents,

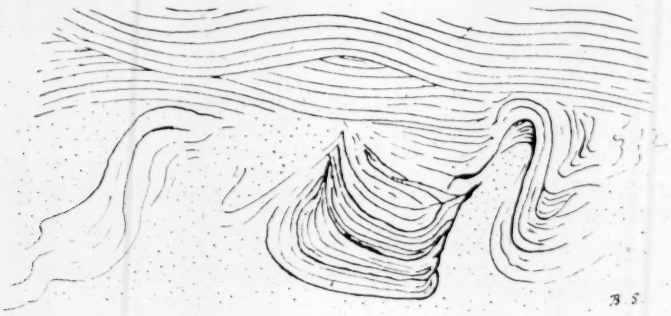


FIG. 1. Stone in wall of Sutton Church, Notts, with contorted laminæ. Nat. size.

would sweep along with them a heavy burden of sand, *and tear up* (Fig. 1) *or contort* underlying ripple-marked layers, embedding them in a structureless deposit. When the flood-waters began to come to rest a layer of ripple-marked sediment passing upwards into drift-bedding (Fig. 2) would be deposited upon the top of the broken[1] and contorted layer.

An actual case of the formation of such structures is quoted by Mr. A. W. Rogers, of the Cape Geological Survey, with whose permission the accompanying photograph (Pl. XXVI, Fig. 2) is reproduced. "At the mouth of the Prieska ravine a certain bed of alluvium on the left bank has its laminæ contorted. They often stand vertically, and are even curved into the shape of an inverted bulb. Above and below this layer the laminæ are false-bedded or lie flat."[2] He attributes

[1] Sorby (Quart. Journ. Geol. Soc., 1908, vol. lxiv, p. 197, pl. xiv) has shown how the sandy ashes of the Langdale slates were deposited sometimes as ripple-drift, which became torn up and contorted as the velocity of the sediment-bearing current increased. Sorby's experiments seem to show that a current of about 2 inches per second in shallow water would suffice to form ripples in sediment as fine as that of these skerries. A velocity of 6 inches per second would wash up and destroy them.

[2] Cape of Good Hope, *Thirteenth Annual Report of Geol. Commission* for 1908, p. 107.

the contortions to swirling waters which he saw above the spot and whose action is clearly traced in the Koegas ravine, where for some 800 yards above the mouth laminated strongly false-bedded alluvium is common, on the left bank dipping up the ravine, on the right bank down the ravine.

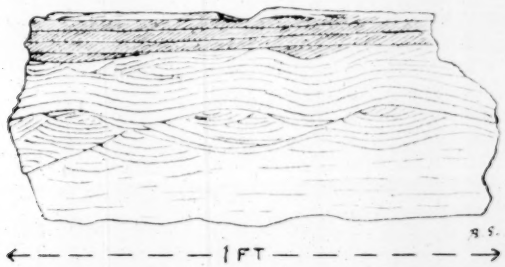


Fig. 2. Stone in south wall of the tower, Fledborough Church, Notts, showing drift-bedding ripples.

In the above example the contorted and brecciated appearance (Fig. 2) seen so frequently in the skerries is reproduced to perfection. It is also to be noted that the laminæ of the dolomitic sandstones are overfolded and tucked away in synclinal form, but no one lamina ever forms a completely closed sphere or ellipsoid as we should expect if the structure was concretionary. In the channel of a stream issuing from a borehole I recently noticed ripple-marks being formed. The sediment was a silt composed of the debris of Coal-measure shales and sandstone and coaly fragments, which formed a deposit not at all pasty; yet pressure of the hand behind some of the ripples caused even this very liquid type of sediment to become contorted or slightly overfolded.

Fig. 3. Stone in wall of Sutton Church, Notts, with broken laminæ. Nat. size.

The idea that the contortions may be due to contraction during dolomitization is dispelled when we remember that the disturbed layer is in many cases both underlain and overlain by a normally ripple-marked layer of identical minerals and percentage composition.

Actual disturbance by water-action is also shown by the occurrence of the above-mentioned pieces of laminated and ripple-marked sandstone in the more compact beds. They have been torn away bodily and carried forward by the rush of muddy water and embedded in curved and twisted patches, which now weather out more easily than the non-laminated matrix.

Depth and Extent of Waters.—Waterstones and Keuper Marls alike were deposited in what was presumably a shallow salt sea or lake of great extent, situated to the east of a southerly projecting spur (the Pennines) of an upland which was under continental climatic conditions; so that in the hot season a great amount of weathering took place in the dry way. In the wet season the debris was swept down into the inland sea, which temporarily increased in extent and depth owing to the influx of fresh water.

All the time that the basin was filling up with sediment the bottom must have been slowly sinking—perhaps most rapidly towards the end of the period—so that the water-level and depth was more or less constant.

The abundance of the skerries in the lower part of the marls and the large deposits of massive gypsum in the higher parts suggests that the waters were deepening and at the same time becoming more saline. But, on the other hand, the skerries never entirely ceased to be formed, and even the higher ones (which contain quartz-grains of two sizes and therefore may indicate deeper water [1]), a long way from the western shore, are ripple-marked and bear salt pseudomorphs; hence the increase in depth must have been trifling. In fact, isostatic conditions seem to have prevailed throughout the area.

The abundance of rather coarse red sandstone, a basal conglomerate, and sandy shales, together with the frequency of salt pseudomorphs, ripple-marks, and sun-cracks,[2] suggests that the Waterstones near their outcrop were accumulated in very shallow water, or even that large tracts with isolated pools were laid bare from time to time. Again, the plant and fish remains found in the Waterstones, and in the Keuper Marls elsewhere, are usually fragmentary, and occur in sediment obviously deposited near a shore-line where the rivers would bring down drift vegetation and render the salt-waters comparatively fresh and suitable for animal life. The fish found by the late E. Wilson at Colwick Wood were supposed by him to have been trapped in the shallows of a lagoon and destroyed either by the waters drying up [3] or becoming increasingly saline. When traced eastward beneath the surface, however, the Waterstones become more like the Marls above them. In a boring at Rampton they were with difficulty separated off from the Marls, and at Lincoln [4] their distinguishing characters are almost wholly absent, only a very little sandstone indeed being present.

Thus in the east we seem to have a more open water area which in the first case was probably quickly flooded, so that the typical shore-line phenomena of the Waterstones were not there developed and the conditions of sedimentation were similar for both Marls and Waterstones.

The thickness of the Keuper between Tuxford and Lincoln is

[1] The coarser sediment of the higher skerries was probably wind-borne to the face of the waters.

[2] I have only seen one slab with casts of sun-cracks from the Keuper Marls of this district.

[3] Dr. H. H. Swinnerton has recently discovered footprints and fish-remains in the Waterstones of Sherwood, Nottingham (GEOL. MAG., May, 1910, p. 229).

[4] According to Mr. Henry Preston, Grantham.

remarkably constant (nearly 900 feet), and contrasts strongly with the variable thicknesses encountered near the old shore-line near Nottingham, a fact which once more emphasizes the uniformity of subsidence and isostatic conditions in the centre of the depression.

The presence of massive gypsum near the top[1] of the division at Newark seems to favour the idea that the water also became increasingly saline. The fibrous and platy gypsum in the lower skerry-belts was no doubt deposited as the marls dried and got rid of their included waters.

Source of Sediment.—As to the source of the dolomite, its detrital nature and manner of deposition show that it was not formed where it is now found, but was probably deposited contemporaneously near the shore-line and then swept out by current-action.

Dr. C. G. Cullis recently reported on the occurrence of small isolated rhombs of dolomite[2] in the Keuper Marls of Westbury-on-Severn and as far north as Worcester. The crystals are extraordinarily perfect and always very minute, and occur in both the red and green marl, sometimes in great profusion. A washed residue of the marl contained practically nothing but quartz-grains and these dolomite rhombs; that is to say, the constituent minerals of the skerries are also scattered throughout the shales and marls associated with them. Dr. Cullis is inclined to think that the dolomite rhombs were precipitated directly from solution. They may have been in the first case; in one band at least (from the Waterstones), which was examined microscopically, the dolomite seems to have been formed in situ. In most cases, however, *the rhombs have suffered attrition by being drifted some distance* together with the quartz and other detrital fragments.

The occurrence of grains of dolomitic sandstone in the higher type of skerry is suggestive, as showing that some dolomitic rocks were also exposed to denudation at this time. Most of the quartz and felspar no doubt was derived from Carboniferous sandstones and grits, and to Carboniferous rocks also we must attribute the basis of the finer calcareous and dolomitic shales and marls.

The Finer Deposits.—Just as there are differences in the lithological characters of the skerries, so also the marls themselves differ from point to point and occur in lithological belts of perhaps as great horizontal extent as the skerries. The differences are brought out by the character of the soils on the outcrop. It is well known that the marls contain a high percentage of silica and are practically fine silts: the coarser silts pass into sandy and dolomitic shales or marls, which break down into a sandy soil; the finer ones behave as tough homogeneous clays. Above a skerry it is common to find sandy shales pass gradually upwards into sandy marl, showing ripple-marks, and then into fine homogeneous marl.

Sorby has shown that such homogeneous clays may be deposited either by gentle and uniform currents drifting along fine sediment to spots where there is scarcely any current at all, or to quick deposit of

[1] Massive gypsum is recorded from a lower horizon at Clarborough, north of Retford.

[2] Rep. Brit. Assoc. for 1907, pp. 506, 507.

cohered mud from tranquil waters. The passage from sandy shales to fine marls mentioned above rather favours the first of these alternatives. In addition we must not forget that wind-borne dust and sand would also add largely to the fine sediment. The rate of deposit in muddy rocks may be as much as 9–18 inches per hour according to Sorby, the shaly character of the coarser parts being due to a gentle current of varying velocity carrying sediment of various degrees of fineness.

We may, then, sum up the formation of skerry-belts as follows:—

(*a*) Rather shallow waters slowly becoming desiccated during a dry period; deposition of fine sediment as marl, some possibly wind-borne and distributed by water, for under favourable conditions even the blocky marls show signs of bedding and current-action. Formation of salt crystals in the upper clayey layers.

(*b*) Influx of fresh water bringing sediment. Casts taken of salt crystals, now dissolved out. Formation of skerry by successive freshets of water and current-action.

(*c*) As supply of coarse sediment failed, laminated shales were deposited, finally passing into fine sediment as marl. Conditions repeated for every skerry.

On this idea, other things being equal, *every individual skerry represents a wet spell* of greater or less duration or degree. A skerry-belt might therefore represent a sequence of wet seasons, and we have an explanation of the persistence of the skerry-belts and general types of sediment over large areas whilst the individual skerries are of less extent.

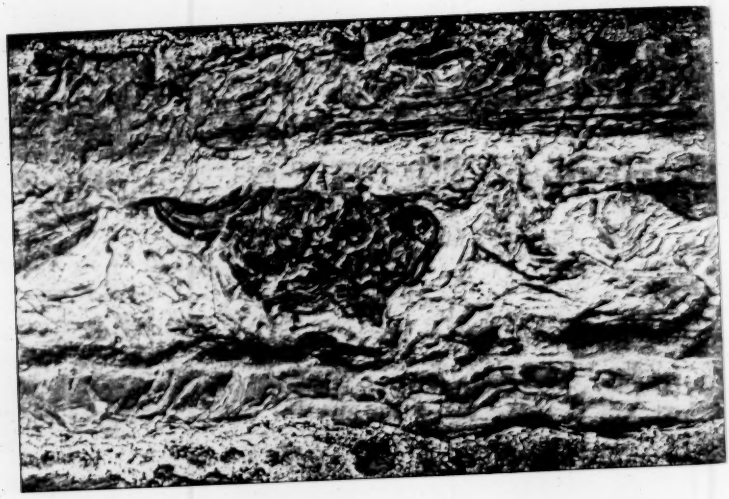
Colour Changes.—A discussion of the variegated colours of the Keuper is beyond the limits of this paper; one or two remarks, however, may not be out of place. We cannot assume that all the red beds were once green, or that all the green beds were once red. There have been changes about tree-roots and along joints where red marl has become green, but the deciding factor for the big colour changes must have been one connected with the mineral solutions in the water and their concentration. In this connexion the above-mentioned gradual change in colour with each skerry when well developed is suggestive. With the influx of fresh waters the conditions which previously brought about a red colour were upset, and a green took its place, followed by alternating red and green conditions until the red finally prevailed as the waters became more concentrated.

Goodchild[1] has pointed out that the presence of organic and humic acids prevents the deposition of iron as ferric oxide—and most of the fossiliferous beds in the Keuper are grey or green. It does not therefore seem too great an assumption to suggest that the first torrential[2] waters sweeping down from the land not only cooled and diluted the previous solutions, but also carried with them organic remains and humic and organic acids which would for a time

[1] "Desert Conditions in Britain": Trans. Geol. Soc. Glasgow, 1898, vol. xi, pt. i, pp. 87, 89, 90.

[2] Especially if humid conditions prevailed in the upper parts of the inland basin as in the case of the Dead Sea and the Great Salt Lake.

1



2

A. W. K.

prevent the formation of red beds and perhaps also bleach the red marl immediately beneath the skerries.

My thanks for criticism and suggestion are due to Mr. G. W. Lamplugh, and to Mr. E. E. L. Dixon whose knowledge of dolomitic rocks is both varied and extensive.

EXPLANATION OF PLATE XXVI.

Fig. 1. Stone, 14 by 7 inches, in the east wall of south porch, Sutton-on-Trent Church, Notts.

,, 2. Broken and contorted alluvial silt in the left bank of the Prieska ravine where it opens on the Orange River.

XI.—*Glyptops ruetimeyeri* (Lyd.), a Chelonian from the Purbeck of Swanage.

By D. M. S. Watson, B.Sc., the Victoria University of Manchester.

THE Manchester Museum contains two 'turtles' from the Middle Purbeck Cap and Feather Bed of Swanage which are referable to Lydekker's[1] *Thalassemys ruetimeyeri*. The first of these, L. 7017, was purchased from Swanage in 1906, and consists of a carapace lacking all the marginals, but otherwise complete and undisturbed. The second, L. 9520, was obtained by the writer from a quarry some 2 miles west of Swanage in March of this year. This specimen, although crushed, is important because it retains the whole shell, both carapace and plastron, with the exception of some of the peripherals.

Description of Specimens.

Carapace (Fig. 1).—The carapace is much depressed and is markedly cordiform. Its length from the anterior end of the nuchal to the posterior border of the last suprapygal is 28 cm., and the maximum width across the third costals is 26 cm. The nuchal is a large hexagonal bone, the anterior edge of which is concave; its dimensions are—length 3 cm., breadth 6·8 cm.

In the two Manchester specimens two distinct bones lie between the inward ends of the first pair of costals; in Lydekker's type-specimen, as is shown in his figure, and as Dr. Andrews has kindly checked for me, there is only one bone occupying the same space.

The first of these bones is probably homologous with that which has been figured by Hay[2] and others in *Chisternon*, *Boremys*, *Aspideretes*, and *Plastomenus* as the præneural; its condition in the present case is very similar to that which obtains in the last three genera. The neurals are generally hexagonal, with the face for the corresponding costal much larger than that for the preceding one. All eight are at present well developed.

Two suprapygals are shown in L. 7017: the first is a hexagonal bone having a short border for the eighth neural and a long curved edge for the second suprapygal. The second suprapygal is quadrilateral and much wider in front. The costals gradually decrease in length from front to back; no pair meets in the middle line, and their form can be best understood from Text-fig. 1.

[1] R. Lydekker, *Catalogue of the Fossil Reptilia in the British Museum (Natural History)*, 1889, vol. iii, p. 149.

[2] O. P. Hay, "The Fossil Turtles of North America": Carnegie Institution, Publ. 75, 1908.

The marginals of the right side of L. 9520 are preserved, although they are somewhat damaged. The fourth, fifth, and sixth have a rounded border; from the seventh to the tenth the edge becomes more and more acute, a change which may be accentuated by the crushing the specimen has undergone. The evidence points strongly to their having been eleven marginals; this is, however, not quite certain owing to the damage L. 9520 sustained at the hands of the quarryman who found it.

The whole surface is enamel-like and polished, the ornament consisting of irregular depressions and ridges; the sutures between bones are crossed by fine striæ at right angles to their direction.

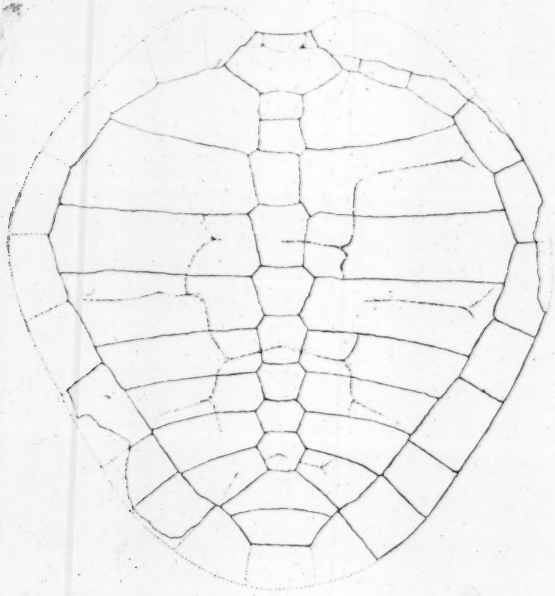


Fig. 1. Restored dorsal view of the carapace of *Glyptops ruetimeyeri* (Lyd.). The bones represented by full lines are present in one or other of the Manchester specimens. The whole carapace within the peripherals is an accurate drawing of L. 7017; the peripherals are added from L. 9520, which is of precisely the same size as L. 7017. The contour of the two anterior peripherals is taken from Lydekker's figure of the type-specimen. I have inserted in the figure all the sulci separating epidermal shields which I have been able to make out on both the Manchester specimens. $\frac{1}{4}$ nat. size.

Plastron.—The plastron is preserved in its natural position in L. 9520; it is flat, and very strongly resembles that of *Pleurosternum*. The anterior end is imperfect, the bridge is long, and the free posterior end narrows until the posterior border ends in a distinct notch.

There are large mesoplastra, which meet in the middle line without appreciably narrowing. The entoplastron was probably rather longer than wide; only a fragment of the left epiplastron remains. The plastron is connected with the carapace by suture of the hyo-, meso-,

and hypo-plastra with the fourth to eighth marginals, and probably also by short and narrow buttresses; the evidence for these is that they have formed marked prominences on the carapace during the crushing which the specimen has undergone. The evidence suggests that the axillary buttress came down on to the first costal, and the inguinal buttress was fixed to the fifth and sixth costals at their junction, but chiefly to the sixth.

The sulci marking the limits of the epidermal shields are very obscure and only slightly impressed on the bones. So far as I have been able to determine them they are entered on Text-figs. 1 and 2. The nuchal shield is, however, quite distinct in both the Manchester specimens. The evidence appears to show that there were no supra-marginals and that the marginal shields lapped slightly on to the costals. On the plastron the sulci are easier to make out; there is a series of infra-marginal shields carried almost entirely on the hyo-, meso-, and hypo-plastra.

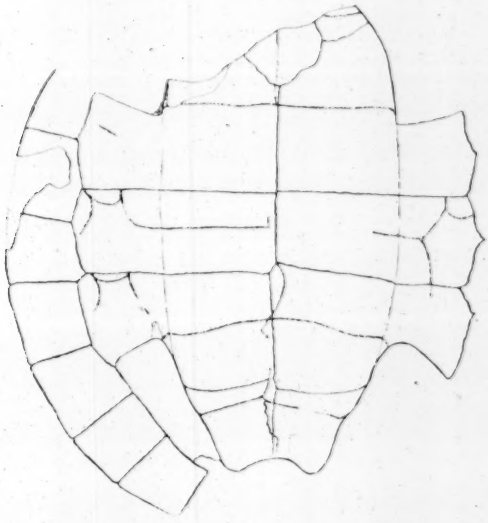


Fig. 2. Plastron of *Glyptops ruetimeyeri* (Lyd.). An unrestored drawing of L. 9520. $\frac{1}{4}$ nat. size.

That the turtle I have described above is identical with Lydekker's *Thalassemys ruetimeyeri* there can be no reasonable doubt: the contour of the carapace and the distribution of the epidermal shields, so far as they can be made out, the form and relations of the nuchal and first suprapygal are very similar, and with the exception of the occurrence of a præneural in the Manchester specimens, such slight differences as there are can be easily accounted for by the fact that the type-specimen is rather smaller than the new specimens, and is therefore presumably rather younger. The plastron, containing as it does large and well-developed mesoplastra, at once removes the species from

Thalassemys and transfers it to the Amphichelydia or Pleurodira. The occurrence of infra-marginals at once puts the Pleurodira out of court.

Hay, in his recent monograph of the fossil turtles of North America, published by the Carnegie Institution, retains two families in the Amphichelydia, the Pleurosternidæ and the Baënidæ. The only differences in the shells of the families are: (1) The Baënidæ have more strongly developed axillary and inguinal buttresses than the Pleurosternidæ; (2) in the Baënidæ the mesoplastra contract strongly as they approach the middle line, whereas in the Pleurosternidæ they retain their full width until they meet. In our species the mesoplastra agree with the condition characteristic of the Pleurosternidæ.

The buttresses cannot be well observed in the Manchester specimens, but judging from the inner aspect of the distal end of the left hyoplastron, which is visible in L. 9520, the axillary buttress must have been small and feeble. Therefore in this character also there is agreement with the Pleurosternidæ. The animal under discussion differs from *Pleurosternum* itself in the presence of a nuchal shield and in the emarginate anterior edge.

The family only contains two other described genera, *Helochelys* and *Glyptops*. *Helochelys* differs markedly from our form in the very loose connexion between the plastron and carapace, and there only remains for comparison *Glyptops*.

This genus was founded by Marsh for a medium-sized Chelonian from the Morrison, Como, or *Atlantosaurus* beds of the United States Upper Jurassic. The type species, *G. ornatus*, is held by Baur to be specifically identical with *Compsemys plicatulus* of Cope. Hay has shown that this species does not belong to the genus *Compsemys*, but represents a very distinct genus for which Marsh's name *Glyptops* must be adopted. Judging from Hay's beautiful figures and excellent description, *G. plicatulus* is extremely similar to our animal: with two exceptions the two agree exactly. The form of the carapace and plastron is similar, the position of the epidermal shields and the ornament are unusually alike; a nuchal shield is said to occur in *G. plicatulus* by Baur. The only differences in fact are these: (1) In our turtle there is sometimes a præneural bone. (2) There are two suprapygals in the English specimens; one of Hay's specimens, the original of his plate vi, is stated to have only one, but his photographic plate shows a crack or suture in a position very similar to that separating the first from the second suprapygal in my specimens. (3) In our turtle the xiphiplastra are rather more deeply notched than in *G. plicatulus*.

The only one of these differences that is at all serious is the first, and as it appears that this difference is liable to occur between individuals of the same species, it can hardly be held to be of generic importance. It thus appears that *Thalassemys ruetimeyeri*, Lyd., should be referred to the genus *Glyptops*, and in future be known as *Glyptops ruetimeyeri* (Lyd.). It deserves to be noticed that *Glyptops* has a large range in time from the Como Beds of the Upper Jurassic to the Denver Beds at top of the Upper Cretaceous; its large range in space is thus rendered much less unlikely.

VII.—The British Earthquakes of the Years 1908 and 1909.

By Charles Davison, Sc.D., F.G.S.

SINCE the Swansea earthquake of June 27, 1906, no strong shock has visited these islands, and, with one exception, all those felt in the years 1908 and 1909 were comparatively slight tremors. The list includes 36 earthquakes, all of them originating in Scotland. The most important were the Dunoon earthquake of July 3, 1908, and the Ochil earthquake of October 20, 1908, the latter being the strongest shock felt in that district during the present century. The remaining tremors occurred in the Ochil district, and the great majority of them would have remained entirely unknown to seismologists had it not been for the interest taken in them by Mr. W. H. Lindsay and Mr. T. J. H Drysdale of Menstrie, Mr. J. Dempster of Airthrey, and Dr. W. L. Cunningham of Alva. To the courtesy of these gentlemen I am indebted for the principal materials of this paper.

1–7. *Ochil Earthquakes: January* 19–*June* 21, 1908.

1. January 19, 1908: 1.27 a.m.—A distinct shock, felt at Menstrie. On February 9, 1908, at 4.6 a.m., a shock, stronger than the preceding, was felt at Menstrie, but only, so far as known, by one observer.

2. May 1, 1908: 6.54 p.m.—A shock of intensity 4 felt at Airthrey, Alva, Dunblane, Menstrie, and Tillicoultry. The shock consisted of one maximum, lasted two seconds, and was accompanied by a loud noise like a muffled explosion.

3. May 2, 1908: 7.5 a.m.—A shock of intensity 4, and lasting three seconds, felt at Airthrey, Alva, and Menstrie. At Airthrey the shock consisted of two concussions, connected by tremors, the latter concussion being the stronger. The shock was preceded, accompanied, and followed by a rumbling noise.

4. May 10, 1908: 12.48 a.m.—A shock of intensity 4, and lasting about four seconds, felt at Airthrey, Alva, Menstrie, Tillicoultry, and Tullibody. At Airthrey and Menstrie the shock consisted of two concussions, the first being much the stronger at Airthrey, and of about the same intensity as the other at Menstrie. Each concussion was accompanied by a loud noise like an underground explosion.

5. May 10, 1908: 12.58 a.m.—A slighter shock than the preceding, but of intensity 4, felt at Airthrey, Alva, and Menstrie. At Airthrey the shock appeared to be single; at Menstrie it consisted of two bumps, the first probably the stronger. The shock was accompanied by a muffled sound like that of an explosion.

6. June 21, 1908: 3 a.m.—A distinct single shock felt at Alva and Menstrie, and at the former place accompanied by a loud noise.

7. June 21, 1908: 4.20 a.m.—A slight but distinct single shock, felt at Menstrie.

8. *Dunoon Earthquake: July* 3, 1908.

Time of occurrence, 6.15 a.m.; intensity 4; centre of disturbed area in lat. 56° 6·7′ N., long. 4° 56·5′ W.; number of records 70, from 15 places, and a negative record from 1 place.

The number of records of the time is 67. Of these 20 are regarded as accurate to the nearest minute, and 17 of them agree in indicating 6.15 a.m. as the correct time.

Notwithstanding the large number of records, for which I am chiefly indebted to the kindness of Mr. G. S. Rae of Kilcreggan and Mr. John Robertson, F.R.G.S., of Strachur, the places at which the earthquake was observed are few in number. It is thus impossible to determine the boundary of the disturbed area with any approach to accuracy. Roughly it is an oval curve, 25 miles long, 21 miles wide, and containing about 400 square miles, with its centre 11 miles north of Dunoon and its longer axis directed about N. 41° E.

At most places the shock consisted of a single series of tremors, its average duration being four seconds. At Strachur, however, two parts were felt by four out of eighteen observers, the average interval between them being three seconds, the first part in each case being regarded as the stronger.

The sound was heard by all the observers. In 27 per cent. of the records it was compared to passing wagons, etc., in 29 per cent. to thunder, in 14 to wind, in 15 to loads of stones falling, in 4 to the fall of a heavy body, in 10 to explosions, and in 1 per cent. to miscellaneous sounds. The beginning of the sound preceded that of the shock in 24 per cent. of the records, coincided with it in 72, and followed it in 4 per cent.; the end of the sound preceded that of the shock in 23 per cent. of the records, coincided with it in 67, and followed it in 10 per cent.; the duration of the sound was greater than that of the shock in 18 per cent. of the records, equal to it in 74, and less than it in 8 per cent.

About four years before, on September 18, 1904, a somewhat stronger earthquake (of intensity 5) was felt in nearly the same district. This earthquake disturbed an area of about 564 square miles, the centre of the isoseismal 5 being 9 miles west of Dunoon and lying on the longer axis of the area disturbed by the earthquake of 1908, and at a distance of about 14 miles in a south-westerly direction from its centre.[1] It is thus very probable that the two earthquakes are connected with the same parent fault, and that the movement along this fault in 1904, while relieving the stress in the portion west of Dunoon, increased the stress in the neighbouring portion of the fault, and thus prepared the way for the movement four years later in the district to the north of Dunoon.

9–14. *Ochil Earthquakes: July* 17 – *October* 20, 1908.

9. July 17, 1908: 5.27 p.m.—A slight but distinct tremor, felt at Alva and Menstrie, and accompanied by noise. Another, but still slighter, shock is said to have been felt at Menstrie after 9 p.m. on the same day; but, as I have no direct evidence from that place, it should be regarded as of doubtful seismic origin.

10. September 2, 1908: 8.16 a.m.—A single shock, of intensity 3, felt at Menstrie, and accompanied by a rumbling noise.

11. September 2, 1908: 8.51 a.m.—A single shock, of intensity 3, felt at Menstrie, and accompanied by a rumbling noise.

[1] Geol. Mag., 1908, Vol. V, pp. 297–8.

12. October 16, 1908: 9.53 p.m.—A tremor, of intensity 4 and duration two seconds, felt at Airthrey, Alva, Blair Ochil (Dunblane), Menstrie, and Red Carr. At Airthrey the shock consisted of one part, at Menstrie of two prominent vibrations or bumps. The sound is compared to an underground explosion, a clap of thunder, or the thud of falling rock.

13. October 19, 1908: 9.18 a.m.—A slight tremor, with sound, observed at Airthrey. The shock was also felt at Blair Ochil (Dunblane).

14. October 19, 1908: 9.39 a.m.—A noise, without any accompanying tremor, heard at Menstrie.

15. *Ochil Earthquake: October* 20, 1908 (*Principal Earthquake*).

Time of occurrence, 4.8 p.m.; intensity 7; centre of isoseismal 6 in lat. 56° 11·4′ N., long. 3° 47·3′ W.; number of records 59, from 34 places, and 20 negative records from 18 places.

This is probably the strongest of all recorded earthquakes in the Ochil district. The intensity was not less than 7 at Alva and Tillicoultry, while that of the earthquake of September 21, 1905, was at no place higher than 6.

Of thirty-six records of the time, eight are regarded as being accurate to the nearest minute. The average of these is 4.8 p.m., which agrees with the majority of estimates.

The only isoseismal which it is possible to draw is that of intensity 6, and this agrees so closely with the corresponding isoseismal of the earthquake of September 21, 1905, that it is unnecessary to reproduce it.[1] Towards the north, west, and south the two curves are almost coincident; towards the east the isoseismal of the later earthquake falls short of the other by about half a mile. Its length is 15 miles, width 10½ miles, and area 123 square miles. Its centre is 3½ miles E. 48° N. of Menstrie, and the direction of its longer axis E. 25° N. The magnitude of the disturbed area is unknown, but it is probably nearly the same as that of the earthquake of September 21, 1905, though slightly displaced to the south, for the shock was felt at several places, such as Falkirk, Polmont, and Bo'ness, which are from one to two miles south of the isoseismal 4 of the earthquake of 1905, while it was not felt at Comrie, Monzie, and Crieff, close to the northern portion of the same curve. From the district lying to the south of the last-mentioned places observations are altogether wanting.

At several places within the isoseismal 6 (such as Alloa, Cambus, Greenloaning, Menstrie, and Tillicoultry) the shock consisted of two distinct parts, separated by an interval of about three seconds, the first part being much the stronger. At other places farther from the epicentre one part only was observed, the effect resembling that caused by the fall of a heavy weight or by the passage of a traction engine. The average of fifteen estimates of the duration of the shock is 2¾ seconds.

The sound accompanying the shock was heard by 92 per cent. of

[1] See Quart. Journ. Geol. Soc., 1907, vol. lxiii, pl. xxvi.

the observers. In 47 per cent. of the records it is compared to passing wagons, etc., in 27 per cent. to thunder, in 17 to the fall of a heavy body, and in 10 per cent. to explosions. The beginning of the sound preceded that of the shock in 33 per cent. of the records, coincided with it in 54, and followed it in 13 per cent.; the end of the sound preceded that of the shock in 19 per cent. of the records, coincided with it in 33, and followed it in 47 per cent.; the duration of the sound was greater than that of the shock in 39 per cent., equal to it in 39, and less than it in 22 per cent.

16. *Ochil Earthquake: October* 20, 1908, 4.13 *p.m.*

Intensity 5; centre of disturbed area in lat. 56° 11·3′ N., long. 3° 48·0′ W.; number of records 18, from 13 places.

The boundary of the disturbed area coincides nearly with the isoseismal 6 of the preceding earthquake, except that it is displaced about half a mile to the west-south-west. The area is 15 miles long, 10½ miles wide, and contains about 123 square miles. Its centre is 3 miles E. 50° N. of Menstrie and half a mile west-south-west of that of the isoseismal 6 of the preceding earthquake, and its longer axis is directed E. 25° N. The intensity of the shock was greatest (namely, 5) at Tillicoultry. The shock was merely a brief tremor, lasting about 1½ seconds, without any prominent vibration or 'thud'. The sound, which attracted but little attention, was compared to thunder or an explosion.

17–36. *Ochil Earthquakes: October* 20, 1908 – *October* 22, 1909.

17. October 20, 1908: 9.26 p.m.—A very slight shock felt at Airthrey and Menstrie. At Airthrey the sound and vibration began together, and terminated simultaneously in a thud.

18. November 6, 1908: 4.45 p.m.—A noise heard at Menstrie.

19. January 19, 1909: 5.28 a.m.—A shock, of intensity 4, felt at Airthrey, Alva, and Menstrie, accompanied by a loud sound.

20. January 19, 1909: 5.29 a.m.—A shock, felt at Menstrie. At Alva two tremors were felt after the shock at 5.28 a.m., but the times are not known.

21. January 23, 1909: 12.15 p.m.—A slight concussion, of intensity 3, felt at Airthrey and Menstrie, accompanied by a noise like that of an explosion underground.

22. January 24, 1909: 12.15 p.m.—A shock, of intensity 3, felt at Menstrie.

23. January 24, 1909: 2.28 p.m.—A tremor felt at Airthrey.

24. January 24, 1909: 3.35 p.m.—A tremor, of about the same intensity as the preceding, felt at Airthrey.

25. January 27, 1909: 1.40 p.m.—A slight shock felt at Menstrie.

26. February 22, 1909: 7.26 p.m.—A noise heard at Menstrie.

27. March 19, 1909: 9.35 a.m.—A shock, accompanied by noise, felt at Menstrie.

28. May 22, 1909: 3.23 p.m.—A shock, of intensity 5, felt at Airthrey and Menstrie; accompanied by a sound like that of an explosion.

29. May 22, 1909: 5.1 p.m.—A shock, of intensity 4, felt at Airthrey; accompanied by a noise like that of a slight explosion.

30. May 22, 1909: 5.24 p.m.—A slight shock felt at Menstrie.

31. May 22, 1909: 8.23 p.m.—A shock, of intensity 5, felt at Airthrey; accompanied by a sound like that of an explosion, the sound being louder than at 5.1 p.m.

32. October 21, 1909: 8.37 a.m.—A concussion, of intensity 4, felt at Airthrey, and followed by a sound like that of an explosion.

33. October 21, 1909: 9.53 a.m.—A slight shock felt at Menstrie.

34. October 22, 1909: 6.55 a.m.—A slight shock felt at Menstrie.

35. October 22, 1909: 7.57 a.m.—A concussion, of intensity 4, felt at Airthrey, preceded and followed by a sound like that of a heavy body falling.

36. October 22, 1909: 9.8 p.m.—At Airthrey, three concussions, separated by intervals of two and five seconds, preceded and followed by sounds like those of sharp explosions.

Origin of the Ochil Earthquakes.

From the only isoseismal line that can be drawn of the earthquake of October 20, 1908, it may be inferred that the direction of the originating fault is about E. 25° N., which agrees closely with that of E. 27° N. obtained from the earthquakes of July 23 and September 21, 1905. The corresponding direction given by the first earthquakes of the present series, those of September 17 and 22, 1900, is E. 11° N. They originated, however, in a more westerly region, so that it is uncertain whether two faults have been in action or a single fault with varying direction.

The Ochil fault passes through or near the Hillsfoot villages, at which alone the slighter shocks were felt, and has a mean direction there of about E. 13° N. Moreover, at several of these places (Menstrie, Alva, and Tillicoultry especially) the shocks attained an intensity which is out of all proportion to the areas disturbed. For instance, the earthquake of October 20, 1908, disturbed an area of about 1000 square miles, while the average area disturbed by a British earthquake of the same intensity is about 27,000 square miles. This points to an extremely shallow origin for the Ochil earthquakes, and therefore favours their connexion with the great fault of the district.

With regard to the hade of the fault, the seismic and geological evidence are at first sight apparently in conflict. In the neighbourhood of Dollar, which is about four miles east of Tillicoultry, it is known to hade to the south. In the district in which the earthquakes originate, that between Airthrey and Tillicoultry, both the course and hade of the fault are unknown. That the originating fault here hades to the north is, however, clear from the relative positions of the isoseismal lines of the earthquake of September 21, 1905, and from the fact that by far the larger portion of the disturbed areas of several of the slighter shocks[1] lies on the north side of the fault. Either, therefore, the great fault changes hade between Dollar or Tillicoultry, or there is another fault in its immediate neighbourhood

[1] Such as those of September 17 and 22, 1900; July 23, October 8, December 28 and 30, 1905; and October 20 (4.13 p.m.), 1908.

which hades towards the north and which is responsible for the stronger earthquakes of the series.

Earth-shake at Stanhope (Weardale): December 2, 1909.

An earth-shake was felt in the mining district of Upper Weardale shortly after 11 a.m. So far as can be judged from the small number of records, the disturbed area was about 7 miles in diameter and about 39 square miles in area. The centre is approximately in lat. 54° 45·1′ N., long. 2° 5·0′ W., or 3 miles west of Stanhope. The shock consisted of one series of vibrations, of intensity 4, and lasting about two seconds. The sound was compared to a heavy train passing, the fall of snow from the roof, or the firing of a heavy shot in a quarry. At Boltsburn a vibration, accompanied by a heavy rumble, was felt in two parts of the mine, and it was at first thought that a heavy fall had occurred.[1] The small disturbed area, the nature and brevity of the shock and sound, and the disturbance in the mine at Boltsburn, all point to a superficial slip precipitated by the working in the mines as the cause of the earth-shake.

Spurious Earthquakes.

Tiverton district: May 25, 1909.—At about 12.55 p.m. shocks were felt at several places in East Devon between Honiton and Tiverton. Windows rattled violently, and indoors tremors were felt, which lasted, with short intermissions, for 15 minutes. At Uffculme a peculiar noise, unlike thunder, was heard for 7 minutes. At other places the sound was compared to the rumbling of heavy guns. That this was the origin of the disturbance is clear from the evident transmission of the waves through the air, the long duration of the disturbance, the nature of the sound, and from the fact that at the time mentioned heavy gun-firing took place in the Channel off Weymouth. Honiton is 35 miles and Tiverton 50 miles west-north-west of Weymouth.

Uyeasound (Shetland Islands): October 9, 1909.—A disturbance, supposed to be that of an earthquake, was felt at Uyeasound, in the island of Unst, at about 2.10 a.m. The shock, which was of intensity 5, consisted of two parts, separated by an interval of 9 seconds. The first and stronger part lasted 28 seconds, and the second 12 seconds. The accompanying sound resembled the noise of wheelbarrows, changing, about the time when the shock was strongest, to that of heavy wagons passing.

So far as I can ascertain, the disturbance was noticed by only a few persons. The duration of the double disturbance is of course far too great for a British earthquake, but observers of a true earthquake occasionally err quite as widely in their estimates. It seems clear, however, that a shock so strong as that reported would have been felt by many persons over a wide area. It is possible that it was caused by thunder, which is said to have been heard the same morning.

[1] I am indebted to the kindness of my former teacher, Professor G. A. Lebour, for the first records of this earth-shake.

REVIEWS.

I.—Catalogue of the Fossil Bryozoa in the Department of Geology, British Museum (Natural History). The Cretaceous Bryozoa, Vol. II. By J. W. Gregory, D.Sc., F.R.S., F.G.S. 8vo; pp. xlviii, 346, 9 plates, and 75 figures in the text. London: printed by order of the Trustees of the Museum, 1909.

THIS volume is the third of a series by Dr. Gregory on the fossil Bryozoa in the National Museum at South Kensington: the first, comprising the forms from Jurassic strata, appeared in 1896; the second, published in 1899, and that now under notice contain descriptions of forms from Cretaceous rocks. The delay of ten years in the appearance of the second part of the Catalogue of Cretaceous Bryozoa has arisen from the retirement of Dr. Gregory from the British Museum and his absence from Europe for several years. In this interval the Museum collections have largely increased, but these later additions, with some special exceptions of species of systematic importance, have not been treated in detail in the present work, but remain over, together with the Cheilostomata, for description in the final volume of the Catalogue, which will be prepared by Mr. W. D. Lang, now in charge of the fossil Bryozoa in the Museum.

At the beginning of the present volume the author contributes an elaborate "Introduction to the Cretaceous Bryozoan Fauna", which, but for various obstacles, should have appeared in the previous volume. It is of a somewhat general character, and deals with many points of interest in connexion with the development of the group during this geological period, some of which may be mentioned.

The author is of opinion that the chief modern types of Bryozoa had their origin in the Cretaceous era, and that a separation line between the Palæobryozoa and Neobryozoa might be drawn most appropriately between the Jurassic and the Cretaceous. The following three orders of Bryozoa pass upwards from the Jurassic into the Cretaceous:—

1. Trepostomata, which comprises forms with a massive zoarium of tubular zoœcia. This order is very numerously represented in Palæozoic rocks, and Gregory has placed in it many Jurassic species and states that it is abundant in the Lower Cretaceous, but both rarer and smaller in the Upper, and it is continued into the Cainozoic. Ulrich, however, the founder of the order, holds that there is no evidence that the group survived later than the Palæozoic era,[1] and he relegates to the Cyclostomata many of the genera which Gregory has transferred to the Trepostomata.

2. Cyclostomata. The Bryozoa of this order are very numerous, and they are predominant in the Cretaceous rocks; the author divides it into the three sub-orders of Tubulata, Dactylethrata, and Cancellata.

3. Cheilostomata. This order makes its first appearance in the Jurassic, but only two species are known in this epoch; it first

[1] Zittel, *Text-book of Palæontology*, Eastman's translation, p. 290.

became important in the Upper Cretaceous, and it is the predominant group of Bryozoa in existing seas.

Under "Descriptive Nomenclature" the author defends his use of the term 'gonocyst' for a peculiar type of ovicell in some of the Cyclostomata on the ground that it differs from a 'gonœcium' in not being due to the modification of a single zoœcium; but Dr. S. F. Harmer, who has worked so extensively on the development of existing Cyclostomatous Bryozoa, raises the objection that in all Cyclostomata the ovicell is probably a modified zoœcium, and therefore declines to accept the term proposed. Dr. Gregory further introduces the word 'epizoarium' instead of 'epitheca', borrowed from the nomenclature of corals, which is considered unsuitable as there is no theca in Bryozoa, and the layer is more important and varied in its functions in this latter group than in corals. 'Cancelli' is another term to which different meanings have been attached; by some it refers to aborted zoœcia in dimorphic zoaria; these, however, are now named 'mesopores' by Dr. Gregory, and cancelli are defined as "spaces of interzoœcial origin which remain either as simple or branched tubuli, or as maculæ, round spots or spaces, in the walls of the zoœcia". But in certain cases, as in the Discoporellidæ (Lichenoporidæ) for example, there is great difficulty in determining whether the small pores are of the nature of 'cancelli' or 'mesopores': if the former, the family would be placed in the C. Cancellata; if the latter, in the Trepostomata!

Dr. Gregory then gives a general sketch of the various classifications proposed for the Cyclostomata by the principal authorities on this group from D'Orbigny onwards, and remarks that it shows an unusually complete divergence of opinion as to the number of subdivisions required and as to their respective affinities. The summary of fifty years' work indicates that a more complex classification is necessary for the fossil fauna than for the living members of the group. It would be possible to work out several different classifications of the Cyclostomata according to the values placed on the various characters. "Thus the nature of the zoarium, the general shape of the zoœcium, the linear, radial, or irregular arrangement of the zoœcia, and the solid or cancellous structure of the skeleton, might each be used as the primary systematic character." Until more is known of the succession and geological distribution of the various forms, any classification of the Cyclostomata must be considered as experimental. That adopted by the author as the most suitable is based partly on zoarial and partly on zoœcial characters, the former being used generally for the families and genera and the latter for the sub-orders. Three chief types of zoœcia are recognized—

(*a*) Simple, tubular, monomorphic zoœcia with solid walls.
(*b*) Zoœcia monomorphic, having walls perforated by cavities—the cancelli.
(*c*) Zoœcia dimorphic, one set being aborted to form supporting elements in the zoarium.

The author is of opinion that the recent zonal collecting in the English Chalk by Dr. Rowe and others shows that the Bryozoa

are often restricted in their range of distribution, and thus of value as zonal fossils. The view formerly held that their specific life was prolonged and that consequently they were of little or no use in marking zones was due to unreliable determinations of species.

The Systematic Description in this volume includes first the Cretaceous Cyclostomata which were not treated in the first volume. Of these the families belonging to C. Tubulata are the Crisiidæ, Theonoidæ, Fascigeridæ, and Osculiporidæ, and to C. Cancellata the family of the Desmeporidæ. The families included in the order Trepostomata are the Cerioporidæ, Heteroporidæ, Zonatulidæ, Radioporidæ, and Cameroporidæ. In the sub-class Phylactolæmata the family Plumatellidæ. There are also additions and corrections to the following families of the Cyclostomata which were described in the previous volume: Diastoporidæ, Idmonidæ, Entalophoridæ, Eleidæ, Horneridæ, Petaloporidæ, and Clausidæ.

In the descriptions of species the same lines are followed as in the earlier parts of the Catalogue; there is first a full Synonymy, then the Diagnosis, Dimensions, Distribution, Figures, and Affinities of the species. Then follows a List of the Museum Specimens of the particular species described, giving the registered number and details of form and size of one or more specimens included under this number; the formation, zone, and locality whence they come; and lastly, the name of the donor or of the collection to which they formerly belonged. Occasionally the specimens under one number are so many as to preclude any attempt to refer to them individually—for example, in "D. 3367. More than 100 specimens".

Dr. Gregory includes in the Catalogue descriptions or references to all known species of Cretaceous Bryozoa, whether represented or not in the Museum Collection, and altogether in this volume 308 species belonging to 67 genera are enumerated. But of this number the collection possesses specimens of only 103 species and 38 genera. Some of the unrepresented forms are known to be of a dubious character, and others may possibly be found in the recently acquired materials not yet fully examined; but allowing for these, it would seem that there are many significant gaps in the collection yet to be filled up.

A very useful List of Chief Localities for Cretaceous Bryozoa (excluding England) and a comprehensive Bibliography are appended. The Subject Index and the carefully drawn up Index to systematic names of Bryozoa afford every facility for reference to the forms described. The figures in the nine plates are excellently drawn; a greater number of plates to allow of further illustrating the interior structure of some of the forms, more particularly of the Trepostomata, would have been desirable.

Students of fossil Bryozoa are greatly indebted to Dr. Gregory and to those who have helped him in the preparation of this and the previous volume on the Cretaceous forms, and they will hail with satisfaction the early completion of the final volume now in the capable hands of Mr. W. D. Lang.

II.—Fossil Plants: A Text-book for Students of Botany and Geology. By A. C. Seward, M.A., F.R.S., Professor of Botany in the University, Fellow of St. John's College, and Hon. Fellow of Emmanuel College, Cambridge. Vol. II.[1] pp. xxii+624, with 265 illustrations. Cambridge: the University Press, 1910 (C. F. Clay, Manager, Fetter Lane, E.C.). Price 15*s*.

WE gladly welcome the arrival of the second volume of this important work, and none the less so that we have waited long and patiently for its advent. In the first volume more than 100 pages are occupied in general matters introductory to a study of fossil plants both from a geological and a botanical aspect. These are followed by a chapter on the Thallophyta, embracing all the simplest forms of vegetative structures—Diatoms, Coccospheres, Rhabdospheres, and the like; Algæ, *Girvanella*, *Schizomycetes*, *Oculites*, *Chara*, and many others. Then come the Bryophyta, Liverworts, Mosses, etc., followed by the Pteridophyta, or Vascular Cryptogams, and the Equisetaceæ; these are continued into and concluded in vol. ii. Here are also placed the doubtful fossil forms, the Psilotales. The Equisetites of the Secondary rocks and their predecessors, *Phyllotheca*, *Schizoneura*, etc., of Triassic and Permo-Carboniferous times, are here described and figured, and the Equisetales, represented by the numerous forms of *Calamites* of the Coal-measures with their wonderful stem-structures, leaves, and spore-bearing cones (strobilites), and *Sphenophyllum*, upon which genus the late Professor Williamson devoted so much patient investigation. They form the concluding chapter in vol. i and the opening chapter in vol. ii. Here is also added an account of the spore-cone of *Cheirostrobus*, Scott. These embrace a most interesting group of fossil plant-remains in which the structure has been preserved in a marvellously perfect manner.

The two recent genera, *Psilotum* and *Tmesipteris*, are usually spoken of as members of the family Psilotaceæ, which is included as one of the subdivisions of the Lycopodiales. It is probable, as Scott first suggested, that these two plants are more nearly allied than are any other existing types to the Palæozoic genus *Sphenophyllum*. *Psilophyton*, another rather obscure fossil plant from the Devonian and Silurian rocks of Canada, is placed near the foregoing, but its true botanical relations are a little uncertain.

The Lycopodiales, like the Equisetales and Calamiteæ, present to us plants having recent representatives and also a great and important series of fossil genera. "A general acquaintance with the extinct as well as with the recent Lycopodiales will enable us to appreciate the contrast between the living and the fossil forms, and to realize the prominent position occupied by this group in the Palæozoic period, a position in striking contrast to the part played by the diminutive survivors in the vegetation of the present day" (p. 30). From the modern club-moss *Lycopodium*, the *Selaginella*, and the *Isoetes*, all humble ground-plants, we pass to Arborescent Lycopodiales, *Lepidodendron* and *Sigillaria*, often spoken of as "Giant Club-mosses", and

[1] Vol. i appeared in 1898 (pp. vii, 452, with 111 illustrations, 12*s*.), and was reviewed in the Geological Magazine for May, 1898 (pp. 228–32).

forming by far the larger part of the forest-like vegetation of the Coal-measures all the world over.

"The genus *Lepidodendron* included species comparable in size with existing forest trees. A tapered trunk rose vertically to a height of 100 feet or upwards from a dichotomously branched subterranean axis, of which the spreading branches, clothed with numerous rootlets, grew in a horizontal direction probably in a swampy soil or possibly under water. A description by Mr. Rodway of Lycopods on the border of a savannah in Guiana, forming a miniature forest of pine-like Lycopodiums, might, with the omission of the qualifying adjective, be applied with equal force to a grove of *Lepidodendra*. The equal dichotomy of many of the branches gave to the tree a habit in striking contrast to that of our modern forest trees, but, on the other hand, in close agreement with that of such recent species of *Lycopodium* as *L. cernuum*, *L. obscurum*, and other types. Linear or oval cones terminated some of the more slender branches, agreeing in size and form with the cones of the spruce fir and other Conifers or with the male flowers of species of *Araucaria*, e.g. *A. imbricata*. Needle-like leaves, varying considerably in length in different species, covered the surface of the young shoots in crowded spirals, and their decurrent bases or leaf-cushions formed an encasing cylinder continuous with the outer cortex. The fact that leaves are usually found attached only to branches of comparatively small diameter would seem to show that *Lepidodendron*, though an evergreen, did not retain its foliage even for so long a period as do some recent Conifers" (p. 93).

"By the activity of a zone of growing tissue encircling the cylinder of wood, the main trunk and branches grew in thickness year by year: the general uniformity in size of the secondary conducting elements affords no indication of changing seasons. As the branches grew stouter and shed their leaves the surface of the bark resembled in some degree that of a spruce fir and other species of *Picea*, in which the leaf-scars form the upper limit of prominent peg-like projections, which, at first contiguous and regular in contour, afterwards become less regular and separated by grooves, and at a later stage lose their outlines as the bark is stretched to the tearing-point. The leafless branches of *Lepidodendron* were covered with spirally disposed oval cushions, less peg-like and larger than the decurrent leaf-bases of *Picea*, which show in the upper third of their length a clean-cut triangular area, and swell out below into two prominent cheeks separated by a median groove, and tapering with decreasing thickness to a pointed base which in some forms (e.g. *Lepidodendron Veltheimianum*) is prolonged as a curved ridge to the summit of a lower leaf-cushion" (p. 94).

"A fully grown *Lepidodendron* must have been an impressive tree, probably of sombre colour, relieved by the encircling felt of green needles on the young pendulous twigs. The leaves of some species were similar to those of a fir, while in others they resembled the filiform needles of the Himalayan Pine (*Pinus longifolia*)" (p. 95).

An interesting explanation is offered of the circular linear scars (*Ulodendron* and *Halonia*) seen on the stem of certain *Lepidodendra* (e.g. *L. Veltheimianum*), and which Mr. Watson, of Manchester, has

regarded as a branch-scar. This hypothesis is further supported by M. Renier, who describes a specimen of *Bothrodendron* from Liège giving indisputable evidence that the scar represents the base of the branch (p. 133). The structures of the spore-bearing cones and the scar and stem-structures of both *Lepidodendron* and *Sigillaria* are elaborately illustrated and clearly described by the author.

As bearing upon the probable aquatic habit of the roots of *Lepidodendron* and *Sigillaria*, known by the name *Stigmaria*, met with so abundantly in the underclays of the Coal-measures, it may not be without interest to record that when the great water-lily lake in Mr. James Yates' garden at Hampstead was drained many years ago, the floor was found to be carpeted with a vast interlaced mass of the roots of *Nymphæa alba* and *Nuphar lutea*, which might have been easily imagined to be *recent* living examples of *Stigmaria ficoides*, their surfaces being covered with circular scars bounded by a raised rim and containing a small central pit. These scars are the bases of attachment of rootlets, and are often to be seen radiating through the shale or sandstone, once forming the muddy semi-aquatic soil on which these Carboniferous forest trees actually grew.

From the forest trees of the Coal we pass to the Filicales, the fossil ferns whose beautiful forms are to be seen often in the roof-shales of our productive Coal-measures. But space does not permit us to dwell upon them here; they fill 300 pages, and deserve a very careful and full notice. Many forms met with in Oolitic shales and in the Wealden are recorded by Professor Seward, as well as the rich series from the Coal-measures. They have more than 100 excellent illustrations to their share.

But we do not permanently part company with Professor Seward, for in his preface he announces his intention to give us a *third* volume to embrace the *Pteridosperms*, other than those briefly described in the final chapter of the present volume, and also other classes of *Gymnosperms*. We are likewise promised some discussion on the fascinating subject of the geographical distribution of plants.

The story of the past floras of the earth, interwoven as it is with that of its living plants, is like the Indian story-tellers' recitals, which last for many days, but we promise Professor Seward—if he does not delay his third volume too long—we will give it as cordial a welcome as we have done vols. i and ii already before the public.

III.—Memoirs of the Geological Survey of England and Wales.

The Geology of the South Wales Coal-field. Part X: The Country around Carmarthen. By A. Strahan, Sc.D., F.R.S., T. C. Cantrill, B.Sc., E. E. L. Dixon, B.Sc., and H. H. Thomas, M.A.; with notes by B. S. N. Wilkinson. 8vo; pp. viii, 177, with 18 text-illustrations. London, 1910. Price 2*s*.

THE area described in this memoir is wholly in the county of Carmarthen, and it is included on Sheet 229 of the colour-printed Geological Survey map. Two editions of this sheet accompany

the memoir, the one with and the other without the Boulder-clay and associated glacial sand and gravel. The drifts do not very seriously obscure the sequence and structure in the Palæozoic rocks which form the foundation of the entire area, and the Drift map will therefore be most useful to geologists. The price of each map is 1*s.* 6*d.*

The geological formations include the Upper Tremadoc of the Cambrian, the Ordovician from the Arenig to the Upper Bala, the Lower Llandovery of the Silurian, the Old Red Sandstone, and the Carboniferous rocks up to the lower part of the Pennant Grit.

The general structure of the area is shown on sections printed on the margin of the map, and here we note that there is some inconsistency in the nomenclature adopted, most of the divisions being indicated by their stratigraphical names, such as Tremadoc Beds and Redhill Beds, others by zonal (graptolitic) names. We think the term Arenig shales would have been better than Tetragraptus Beds from a practical point of view.

A most difficult country is that in the northern part of the area, where the Lower Palæozoic rocks are folded, inverted, and faulted, and shales of different ages and sometimes of similar character are brought into abrupt contact; but the authors have thoroughly elucidated the geological structure by their careful and detailed researches in the field, by the collection of fossils, and with the aid of Dr. Ivor Thomas in the Museum at Jermyn Street, of Mrs. Shakespear in the determination of the Graptolites, of Mr. P. Lake with regard to Trilobites, and of Dr. C. A. Matley with Brachiopods. Most of the disturbances affecting the Lower Palæozoic rocks took place prior to the deposition of the Old Red Sandstone, and between these groups there is everywhere great unconformity.

Remains of *Cephalaspis* and *Pteraspis* are recorded from the Lower Old Red Sandstone; and some plant-remains, *Artisia* and *Stigmaria*, identified by Dr. R. Kidston, have been found in the Penlan quartzite near Kidwelly, a rock assigned to the Upper Old Red Sandstone. The complex zonal divisions in the Carboniferous Limestone Series are described, and attention is then directed to the Millstone Grit and Coal-measures, which occupy the south-eastern portion of the area and form the western part of the main South Wales Coal-field. A small tract of the less productive coal-field which extends into Pembrokeshire is shown on the western margin of the map. The details in the Lower Coal Series form the most important practical part of this memoir. There are also notes on various economic products, including lead-ore, silica-stone (used for making fire-bricks), building-stones, etc.

Among Drift deposits the occurrence is mentioned of two patches of sand at an altitude of more than 500 feet above sea-level east of Eglwys-Cymmyn. A shaft was sunk in 1906 to ascertain the nature of the strata, and 30 feet of sand, loam, and gravel were penetrated. It is noted that the sand contains an assemblage of minerals almost identical with that which was determined by Mr. H. H. Thomas in the Lower Pliocene Sands of St. Erth and St. Agnes in Cornwall. No fossils were obtained from the Welsh strata, which may have been deposited during the Glacial Period.

IV.—Transvaal Mines Department, Geological Survey.

The Geology of the Pilgrims Rest Gold Mining District. By A. L. Hall, B.A., F.G.S. 8vo; pp. 158, with 20 text-illustrations, 33 plates, and geological map. Pretoria, 1910. Price 7*s.* 6*d.*

IN addition to the admirable reports issued annually since 1903 by Mr. H. Kynaston, the Director of the Geological Survey, five separate memoirs on special areas, accompanied by colour-printed geological maps, have been issued. The latest of these memoirs, No. 5, is the one now before us. The map represents portions of the Lydenburg, Zoutpansberg, and Barberton Districts, an area of about 2600 square miles. The geological formations belong mostly to the Transvaal System: a great series of shales, sandstones, and quartzites, dolomitic limestone and chert, in ascending order, divided into the Black Reef Series, Dolomite Series, and Pretoria (or Lydenburg) Series. These rocks are generally grouped as pre-Devonian, or as pre-Cape rocks, their age being somewhere between Devonian and Archæan. Correlation is not attempted in the memoir.

As a gold-producing district that of Pilgrims Rest ranks in the Transvaal next after the Rand, the output for the year 1909 amounting to a little over £400,000 in value. Mr. Hall remarks that the reefs occur more especially in the Dolomite and Black Reef Series, and mostly as "interbedded ore sheets, and thus behave stratigraphically exactly like the sedimentary strata in which they lie". Apart from these "flat reefs", there are less important "cross reefs" which strike across the formations. The author, however, points out that "certain features are persistent and characterize both varieties of reefs. These are the essentially quartzose nature of the reef and the constant association with metallic sulphides, notably pyrites and occasionally copper ores. It is therefore probable that the principles controlling their formation are essentially the same". He concludes that "the gold was introduced in soluble form by the circulation of underground waters carrying silica and iron in solution, the gold being precipitated mainly as the result of the reduction of the iron to the ferrous condition".

Full particulars are given of the strata, and of the intrusive and contemporaneous igneous rocks in the Transvaal System. The geological structure is shown in a number of sections, and the physical features and rock-structures are represented in a series of excellent photographic plates. Among these is a fine view of the Devil's Window, north of Belvedere, in the escarpment of the Drakensberg, looking towards the low country.

V.—Colonsay, one of the Hebrides: its Plants, their local names and uses; Legends, Ruins, and Place-names; Gaelic names of Birds, Fishes, etc.; Climate, Geological Formation, etc. By Murdoch McNeill. pp. vii, 216. Edinburgh: David Douglas, 1910. Price 2*s.* 6*d.* net.

COLONSAY with its adjunct Oransay, for they are connected for several hours during low water, is about 12 miles in length and 3 in breadth. As represented on Sir Archibald Geikie's map of

Scotland, the joint island is formed mainly of Torridonian grits and flags, with Lewisian gneiss in the north, and elsewhere small areas of limestone, eruptive rocks, and raised beach. A more detailed geological sketch-map was published by Mr. W. B. Wright in 1908,[1] based on field-work carried out in the course of the geological survey by Mr. E. B. Bailey and himself. It would have been well if this map had been reproduced in the volume before us, especially as the author acknowledges help from Mr. Bailey, who has "corrected and amplified the chapter on Geology". As it is, there are no illustrations of any kind in the volume, although the object of the author in his chapter of fourteen pages on the "Geological Formation" is to note the relations of the rocks to the landscape and the flora.

The limestone, described under the name of Colonsay limestone, appears to form part of the Torridonian Series, resting on flags and being overlain by phyllites, and in places by the granitic rock of Scalasaig. The author describes the various types of rock and their economic uses, and notes that the so-called "Scalasaig granite" is a diorite.

The occurrence of boulder-clay in hollows in various localities is mentioned, and the effects of glaciation are noted in the rounded outlines and smoothed and striated surfaces of the rock-formations. In comparing the rocks and flora the author observes that there is more in common between the floras of Colonsay and those of the schistose and gneissose islands of the Outer Hebrides than there is between the Colonsay plants and those of the basaltic islands of the Inner Hebrides. Nevertheless, the soils on Colonsay are naturally influenced by the erratic materials of the Boulder-clay and by the Raised Beach deposits.

The work cannot fail to be a useful guide to the visitor who is interested in Natural History, as may be judged from the title which we give in full.

VI.—Man as an Instrument of Research. Presidential Address of G. W. Lamplugh, F.R.S., to the Hertfordshire Natural History Society, April 12, 1910.

ONE would hardly accuse Mr. Lamplugh of being a wag; yet the instrument that comes to one's mind more often than any other when dealing with scientific men is connected with boring. For most scientific men are so wrapped up in their little subject that the great world and its issues are lost sight of. We are grateful to Mr. Lamplugh for one sentence—"Everyone who has tried to translate his observations into accurate description must have felt the inadequacy of language." It is a commonplace, but so true! He has, again, touched up those who, having large collections of material or fact, remain mute and neither use them nor allow others to use them to their full advantage. We disagree with him when he advises people to "record simple facts alone, without attempting to demonstrate their intricate relationships or to trouble himself with the technicalities by which these relationships are conventionally expressed". There

[1] Quart. Journ. Geol. Soc., lxiv, p. 298.

is far too much slipshod stuff published now, and a word with a more experienced friend or with an intelligent editor would bring much of this sloppy, half-baked material into line with more mature writing, and render comparison and correlation much easier. The author does not deal with the somewhat threadbare subject of "the pursuit of knowledge for its own sake", which may be a purely selfish proceeding. At the present day it is more generally recognized that work of all kinds should be for the benefit of the community, and that the highest forms of research, like those of Pasteur and Koch, are such as are calculated to ameliorate the sufferings of humanity.

VII.—Brief Notices.

1. Fossil Insects.—Dr. Anton Handlirsch, who has so elaborately worked out the history of fossil insects, is now actively at work describing the various new forms discovered in the rocks. We have before us a collection of his recent papers, and call attention to the following. "Ueber die fossilen Insekten aus dem mittleren Oberkarbon des Königreiches Sachsen" (*Mitth. Geol. Ges. Wien*, 1909, ii). These consist of Blattoid wings, and include a new genus, *Apophthegma*. Another Blattoid, *Pedinoblatta*, n.g., from the Franken Trias, appears in *Abh. Nat. Ges. Nürnburg*, 1910, xviii, the wing being carefully drawn and figured; while yet a third protorthopteron, *Chalcorychus Walchiæ*, is described in the author's "Ein neues fossiles Insekt aus den permischen Kupferschiefern der Kargala-Steppe (Orenburg)" (*Mitth. Geol. Ges. Wien*, 1909, ii).

Dr. Handlirsch discusses the "frühjurassischer Copeognathen und Coniopterygiden" and "das Schicksal der Archipsylliden" in the *Zoologischen Anzeiger*, 1909, xxxv, and in the number of the same publication for May 10, 1910, gives a brief note—"Ueber die Phylogenie und Klassifikation der Mecopteren." A full report of his lecture "Ueber Relikten" will be found in the *Verh. k.k. zool.-botan. Ges. Wien*, 1909, a lecture which dealt with many other forms besides insects; and a criticism of M. Fernand Meunier and his work on fossil insects, privately printed in 1906, may be lost sight of if not mentioned in these pages.

2. Catalogue of Photographs of Geological Subjects, prepared by the Geological Survey and Museum. 8vo; pp. 35. London, 1910. Price 6*d*.—During the past six years the Geological Survey has taken photographs of objects of geological interest in the areas of England and Wales that were being re-surveyed on the 6 inch maps. In Scotland photographic work was commenced by the Geological Survey in 1890, and a catalogue of the photographs preserved in the Edinburgh Office is promised. In the present pamphlet 800 subjects are recorded, and they relate mostly to Cornwall, Devon, Pembroke, and Carmarthen. They include quarry sections, tors, raised beaches, stream-tin works, dykes, pillow-lavas, sand-dunes, crush-breccia, china-clay works, cleavage, contorted strata, etc. It is noted by the Director, Dr. Teall, that negatives, prints, lantern slides, or bromide

enlargements can be obtained of any of the photographs on application being made at the Geological Survey Office in Jermyn Street, where prints may be seen.

3. Annual Report of the Iowa Geological Survey, vol. xix, for 1908, dated 1909.—This volume contains a full report on the coal deposits of the State by Mr. Henry Hinds, and a history of the coal-mining, which dates back to about 1840, by Mr. J. H. Lees. The peat deposits of Iowa are described by Mr. S. W. Beyer. Analyses of both coals and peat, also bibliographies of these subjects, are given.

4. The Quality of Surface Waters in the United States.—This important subject is dealt with by Mr. Dole (Water Supply Paper, No. 236, of the U.S. Geol. Survey, 1909) in a work of which part i contains the results of over 5000 mineral analyses of water from the principal rivers of the United States east of the Rocky Mountains. Daily samples of water from nearly 200 stations were collected for a year, united in sets of ten consecutive samples from the same stream and station, and the composite was then subjected to analysis. The analyses, giving as they do the average composition of the waters, the fluctuations of composition from day to day, and information regarding change of water-level wherever available, form the most complete collection of data regarding the quality of American rivers that has ever been published. They are on this account particularly valuable to railroad engineers and to managers of industrial plants and waterworks.

REPORTS AND PROCEEDINGS.

Geological Society of London.

May 25, 1910.—Professor W. W. Watts, Sc.D., M.Sc., F.R.S., President, in the Chair.

The Address which it is proposed to submit to His Majesty the King, on behalf of the President, Council, and Fellows, was read as follows, and the terms thereof were approved:—

"To the KING'S MOST EXCELLENT MAJESTY.

"May it please Your Majesty,

"We, Your Majesty's most dutiful and loyal subjects, the President, Council, and Fellows of the Geological Society of London, humbly beg leave to offer to Your Majesty our deepest and most heartfelt sympathy in the great and sudden sorrow which has fallen upon you, and most respectfully to express the grief that we, in common with all Your Majesty's subjects, feel at the great loss which has afflicted the Nation and the Empire in the tragic death of our late beloved and revered Sovereign King Edward VII, in the full vigour of his services for the welfare of humanity and the peace of the world.

"In the depth of our sorrow we find comfort in the assurance that the sceptre of our wise King passes into the hands of one who will keep ever before him the high destiny of the Nation, and we venture humbly to offer our fervent congratulations to Your Majesty on your accession to the Throne, which, under the sway of your ancestors, has become the greatest in the world.

"We trust that the knowledge of the mineral structure of the earth, for a century

the special care of this Society, may continue to grow and flourish under the rule of Your Majesty as it has done under that of your illustrious predecessors.

"That Your Majesty's reign may be a long one and that it may overpass in lustre even those of the great Kings and Queens that have preceded you, is the earnest prayer of your devoted subjects."

The President then read the draft of a circular letter regarding the enhanced price of the Geological Survey Maps, which is to be sent to all institutions in the United Kingdom that are likely to be interested in the matter, bespeaking their support for a respectful representation to the Lords of H.M. Treasury. A draft of the terms in which this representation is to be made was also read.

The following communications were read:—

1. "Dedolomitization in the Marble of Port Shepstone (Natal)." By F. H. Hatch, Ph.D., M.Inst.C.E., F.G.S., and R. H. Rastall, M.A., F.G.S.

The Port Shepstone marble is shown by chemical analysis to be a dolomite (the molecular ratio of calcium carbonate to magnesium carbonate being as 3 : 2). It owes its marmorization to thermal metamorphism by an extensive intrusion of granite, which completely surrounds it and penetrates it in broad dykes. This instrusion took place at some time prior to the deposition of the Table Mountain or Waterberg Sandstone, and is therefore pre-Devonian. The dolomite is relegated to the Swaziland Period.

The metamorphism of the dolomite under normal conditions is shown to have produced a saccharoidal marble of coarse texture, consisting almost entirely of carbonates; and the fact that neither periclase nor brucite has been produced in the normal marble is taken to indicate that the high-pressure conditions obtaining during the metamorphism precluded dedolomitization. In those places, however, where the dolomite contains blocks or boulders of earlier granitic rocks, interaction took place between the magnesium and calcium carbonates of the dolomite and the silica and alumina provided by the inclusions, resulting in the production, in the zone of marble immediately surrounding the inclusions, of a number of interesting silicates of magnesium, calcium, and aluminium, such as olivine, forsterite, diopside, wollastonite, and phlogopite, as well as the oxides brucite and spinel. Magnesian compounds predominate, the excess of lime recrystallizing as calcite. A noteworthy feature is the absence of minerals such as garnet and cordierite, which are especially characteristic of low temperature metamorphism, thus indicating the prevalence of a high temperature during the metamorphism of the dolomite.

The paper concludes with a reference to the occurrence of granite boulders as foreign inclusions in other limestones, and a discussion of the chemical reactions by which the formation of the above-mentioned minerals may be theoretically explained as a result of dedolomitization. Comparison is made with the dedolomitized Cambrian limestones of Assynt and Skye described by Dr. Teall and Mr. Harker, from which the Port Shepstone occurrence differs in the localization of the affected areas to reaction rims around foreign boulders, and in the part played by alumina in the formation of new minerals.

2. "Recumbent Folds in the Highland Schists."[1] By Edward Battersby Bailey, B.A., F.G.S.

A description is presented of the stratigraphy and structure of a considerable portion of the Inverness-shire and Argyllshire Highlands. The district considered lies south-east of Loch Linnhe, and extends from the River Spean in the north to Loch Creran in the south.

The following conclusions are arrived at:—

(1) The schists of the district are disposed in a succession of recumbent folds of enormous amplitude—proved in one case to be more than 12 miles in extent.

(2) The limbs of these recumbent folds are frequently replaced by fold-faults, or 'slips', which have given freedom of development to the folds themselves.

(3) The slipping referred to is not confined to the lower limbs of recumbent anticlines, and is therefore due to something more than mere overthrusting. It is a complex accommodation-phenomenon, of a type peculiar perhaps to the interior portions of folded mountain chains. In fact, the cores of some of the recumbent folds have been squeezed forward so that they have virtually reacted as intrusive masses.

(4) In the growth of these structures many of the earlier formed cores and slips have suffered extensive secondary corrugation of isoclinal type.

The Secretary read the following extracts from a letter received from Mr. C. T. Clough, who was unable to be present at the meeting:—

"I think that special attention may be called to the similarity of the effects produced on all the beds in the attenuated limbs of the slip-folds; the hard massive quartzites, for instance, are not on the average any better preserved than the Leven Schists. This seems contrary to what we should expect *a priori*, and it is contrary also to what we find in some areas affected by the post-Cambrian thrusts of the North-West Highlands. For instance, near Ord in the Isle of Skye, just under the western limb of the folded Sgiath-bheinn an Virid thrust the Fucoid Shales become thinner as the thrust is approached, and are ultimately almost entirely squeezed away from between the Pipe-Rock on the one side and the Serpulite Grit on the other.

"It is interesting to consider what may be the relations in age between the slips described by the author and the Moine thrust. The Moine Schists had certainly been folded intensely, and were much in the same condition as they are now, before the actual snap of the thrust took place. The slips of the Ballachulish district seem much more closely connected with the folding. This difference suggests the question whether, in the Moine Schists a little east of the Moine district, slips of the Ballachulish type may not also occur. It is certainly the case that the beds in the opposite limbs of some of the folds east of the Moine thrust show a marked want of correspondence. The differences have hitherto generally been explained by the supposition that the folds concerned were of unusually great depth, so that they brought into proximity beds which originally were widely separated and were formed under different conditions of sedimentation. It seems very possible, however, that the differences may in some cases be due to the presence of slips accompanying the folds. If such slips do occur not far east of the Moine thrust, as is thus suggested, we may be tolerably certain that they are somewhat older than it.

"In conclusion, I should like to express my high appreciation of the perseverance and enthusiasm with which the author has carried out these investigations. I feel confident that his general conclusions may be accepted as correct, and that they mark a great advance in the study of the tectonics of the Scottish Highlands."

[1] Communicated by permission of the Director of H.M. Geological Survey.

CORRESPONDENCE.

THE IGNEOUS ROCKS OF THE NORTHERN END OF THE RED SEA.

Sir,—During the year 1909 I paid two visits to the north end of the Red Sea. During these visits I made a careful examination of the igneous rock-masses forming a large portion of the Island of Shadwan and the hill ranges of Jebel Esh, Jebel Um Dirra, and Jebel Zeit on the mainland. It is my intention to describe these rocks in a future paper, and to deal with their relations to one another. The rocks consist chiefly of soda-granites, quartz-felsites, diorites, and intrusive dolerites. The granites are occasionally gneissose, and in such case they are usually accompanied by schists, as on the Island of Shadwan. At other times they merge into the most perfect granophyres of a very acid nature. The relations of these rocks to one another, and to the overlying sedimentary rocks, present problems of more than ordinary interest in the study of the geology of this part of Egypt.

Arthur Wade.

Imperial College of Science and Technology,
Royal College of Science, S. Kensington, S.W.
June 8, 1910.

THE PITFALLS FOR ELEPHANTS IN AFRICA: IN REFERENCE TO DEWLISH.

Sir,—It will be remembered that the Rev. Osmond Fisher, F.G.S., at the Geological Society in 1904 [1] read an interesting paper on the possibility of the remains of *E. meridionalis* found at Dewlish having been snared in a pitfall. Apropos of the narrowness of the trench Mr. A. B. Lloyd has some remarks which may possibly be of interest in connexion with the subject.[2] "On 15th [July, 1903] I . . . camped at Kajura, and at this place had my first adventure . . . My nose in the air and my ears set to catch the slightest sound, while I strained every muscle to push myself forward through the thicket, when there was a sudden airy feeling underneath, and the next moment I found myself jammed hard and fast in a regular death-trap set for antelope. It was a pit about 2 feet wide at the top but narrowing at the bottom to a few inches, the total depth being over 10 feet . . . These holes are dug by the natives in all the game country, and the mouth of the pit is usually very skilfully covered over with a layer of thin twigs and grass . . . I have seen them specially made for elephant."

R. Ashington Bullen.

Hilden Manor, Tonbridge.
June 17, 1910.

[1] Q.J.G.S., February, 1905, vol. lxi, p. 38.
[2] A. B. Lloyd, *Uganda to Khartoum*, pp. 96, 97, 98.

THE TERM 'LATERITE'.

SIR,—The question as to the use of the term 'laterite' raised by me in the September number of last year's GEOLOGICAL MAGAZINE has figured in so many subsequent numbers that I feel some diffidence in asking you to publish any further remarks on the subject. I am indebted to Dr. Evans for an expression of his views, based as they are, I note, on an intimate acquaintance with the material to which the name was first given. There is a tone of remonstrance in Dr. Evans' letter that may appear justifiable under the circumstances, but I venture to think that this has led the writer a little astray from the path of argument and to lose sight of the main issue, which is the practicability at the present day of forcing a new definition of laterite on geologists and engineers, or, indeed, the right of anyone to do so. Dr. Evans is more concerned on account of my opinion that the term is of little use as matters stand now, and falls into the error of crediting me with the statement that it "must be abandoned". For my part, if I treat some of the points raised very briefly, I trust it will be clear that I do so only in order to save your space.

In Dr. Evans' third and fourth paragraphs I cannot see that a strong case is developed against calling highly aluminous laterite 'bauxite', and would refer to the quotations in my last letter, which appear to have been passed over. Dr. Evans is doubtless aware that in *Mineral Industry* some Indian laterites have been referred to as bauxites. Perhaps 'aluminous laterite' as opposed to 'ferruginous laterite' would be more acceptable? My point is that the term 'laterite' alone should not be held to imply the presence of free aluminium hydroxides in quantity, because that was not the original significance of the term, and because that is not implied by the chief users of the term at the present day.

In paragraph 5 Dr. Evans asks what could be more suitable for this well-characterized formation than the name Buchanan applied to it over a century ago. What indeed? But why attach to the name Buchanan gave a new definition that has no etymological connexion with it?

With regard to Dr. Evans' eighth and final paragraph, I cordially agree with him that the application of the rule of priority is needed here, but I cannot agree with him when he says that the term 'laterite' has continued in use with the same significance ever since 1807. It is surprising that the derivation of the word should be so completely ignored by those who make this statement.

It will be remembered that this correspondence commenced because a reviewer stated that only products of weathering containing free aluminium hydroxides in hot, moist climates should be considered as laterite. The presence of these hydroxides in Indian laterites became generally known in 1903, but prior to that year the name had spread to other countries, where it was used, not always in strict accordance with Buchanan's definition, for ferruginous weathering products that are useful in public works. No one denies the great interest of the discovery that Indian and other laterites contain free aluminium hydroxides, but it is questionable whether that gives